Engineering Library

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

VOL. CXIV.—No. 2960.] *LONDON: FRIDAY, SEPTEMBER 22, 1922.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

Aveling & Porter, Ltd., ROCHESTER. 9663

Steam Road Rollers & Tractors.

A. G. Mumford, Ltd., CULVER STREET WORKS, COLCHESTER. ON ADMIRALTY AND WAR OFFICE LISTS. ENGINES for Torpedo Boats, Yachts, Launches. BOILER FEED PUMPS. See advertisement pages 25 and 33. PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS. And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant OF ALL DESCRIPTIONS. FLOATING CRANES. COAL BUNKERING VESSELS.

Werf Conrad, HAARLEM, HOLLAND. Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C. 2. *See half-page Advert. last week and next week.* 675

Cranes.—Electric, Steam, HYDRAULIC and HAND, of all types and sizes. GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 9048

STEEL TANKS, PIPES, GASHOLDERS, &c.

Thos. Piggott & Co., Limited, BIRMINGHAM. 7411 See Advertisement last week, page 23.

"Spencer-Hopwood" Patent WATER TUBE Boilers. *See page 26.* 577 Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives. Specification and Workmanship equal to Main Line Locomotives. R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 9044

Cochran MULTITUBULAR AND CROSS-TUBE TYPES. **Boilers.** See page 17. 9047

Petter Oil Engines. For Paraffin and Crude Oil. Sizes 1½ B.H.P. and upwards.

Petters Limited, Yeovil. Sizes 25 to 500 B.H.P.

Vickers-Petters, Ltd., Ipswich See advertisement alternate weeks. 9225

Invincible Gauge Glasses.

BUTTERWORTH BROS., Ltd., Newton Heath Glass Works, Manchester. Od 9783

Electric Cranes. 9663 S. H. HENWOOD & CO., LTD., RHDDISH.

Fuller, Horsey, Sons & Cassell. SPECIALISTS in the SALE AND VALUATION of 1834 PLANT AND MACHINERY and ENGINEERING WORKS. 11, BILLITER SQUARE, E.C.3.

Iron and Steel

Tubes and Fittings. Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817

The Scottish Tube Co., Ltd., HEAD OFFICE: 24, Robertson Street, Glasgow. See Advertisement page 81, Sept. 15.

YARROW & CO. (1922), LTD., GLASGOW.

PASSENGER AND CARGO STEAMERS,

SHALLOW DRAFT VESSELS. 818

Campbells & Hunter, Ltd. Gear Cutting. Worm Wheels cut up to 13 ft. diam. Bevel and Mitre Wheels planed up to 3 ft. diam. Spur Wheels cut up to 9 ft. diam. DOLPHIN FOUNDRY, LEEDS. 4547

VOSPER & Co., LTD., PORTSMOUTH. SHIP & LAUNCH BUILDERS, Od 2561 ENGINEERS & BOILER MAKERS.

Cement.—Maxted & Knott, LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest references. Established 1900. Address, BURNETT AVENUE, HULL. Cablegrams: "Energy, Hull." 9762

OIL FUEL APPLIANCES, *Systems* PRESSURE, AIR, STEAM *For Boilers of all types.* KERMODES LIMITED, 35, The Temple, Dale Street, Liverpool. *Naval Outfits a Speciality,* also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds. Supplied to the British and other Governments. Telephone No.: Central 2832. Telegrams: "Warmth." 4078

Locomotives Tank Engines designed and constructed by MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od 3487 See their Illus. Advertisement, page 97, last week.

RAILWAY AND TRAMWAY ROLLING STOCK.

Hurst, Nelson & Co., Ltd. THE GLASGOW ROLLING STOCK AND PLANT WORKS. MOTHERWELL. Od 2583

R. Y. Pickering & Co., Ltd., (ESTABLISHED 1864.) BUILDERS of RAILWAY CARRIAGES & WAGONS. MAKERS of WHEELS and AXLES of all kinds. RAILWAY WAGONS FOR HIRE. Chief Works and Offices: WISHAW, near GLASGOW. London Office: Od 8383 2, VICTORIA STREET, WESTMINSTER, S.W.

Henry Butcher & Co., AUCTIONEERS, VALUERS AND SURVEYORS for ENGINEERING AND ALLIED TRADES and INDUSTRIAL PROPERTIES. 9066 63 and 64, CHANCERY LANE, LONDON, W.C.2.

Electric Transporters. S. H. HENWOOD & CO., LTD., 9662 RHDDISH.

John H. Wilson & Co., Ltd., Birkenhead.

See Illustrated Advertisement Page 100, Jan. 28, 1921.

Locomotive Shunting Cranes

Steam and Electric Cranes EXCAVATORS, CRANE-NAVVIES, CRABS, CONCRETE-MIXERS, SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY. 657

LISTS OF STANDARD SIZES ON APPLICATION.

London Office: 16, VICTORIA STREET, S.W. 1.

John Bellamy, Limited, MILLWALL, LONDON, E. 1216 GENERAL CONSTRUCTIONAL ENGINEERS,

Boilers, Tanks, & Mooring Buoys STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL

Tubes AND Fittings AND **Steel Plates.**

STEWARTS AND LLOYDS, Ltd. GLASGOW - BIRMINGHAM - LONDON. See Advertisement Page 76. 9052

Economy! HIGH BOILER EFFICIENCIES ARE OBTAINED BY INSTALLING **Todd Oil Burners** FUEL OIL BURNING SYSTEMS, HEATERS, STRAINERS. 49-51, EASTCHEAP, LONDON, E.C. 3.

TODD SHIPYARDS CORPORATION, Builders of Steam and Motor Ships, Repairers, Electric Drive Installations. Twenty-one Floating Docks, Two Graving Docks, Twelve Shipways. 25, Broadway, New York, U.S.A. 9660

The Glasgow Railway Engineering Company, GOVAN, GLASGOW. LTD., London Office—12, Victoria Street, S.W. MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES. CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 540

SPECIFY WELDLESS STEEL CHAIN.

The Strongest Chain IN THE WORLD. 898 Sole Manufacturers: WELDLESS CHAINS, LTD., 80, WELLINGTON STREET, GLASGOW.

Brett's Patent Lifter Co. LIMITED. **Hammers, Presses, Furnaces,** COVENTRY. 510

THE GLASGOW ROLLING STOCK AND PLANT WORKS.

Hurst, Nelson & Co., Ltd., Builders of RAILWAY CARRIAGES, WAGONS, ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK. Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS, PRESSED STEEL WORK OF ALL KINDS. Registered Office and Chief Works: Motherwell. London Office: 14, Leadenhall Street, E.C. Od5282

Electric Lifts (UP TO 25 TONS.) 9663 S. H. HENWOOD & CO., LTD. RHDDISH.

Designs, Drawings, Tracings. Working Drawings made from clients sketches and instructions. Single purpose machines designed. Drawings prepared for patent specifications, and all classes of tracing undertaken. Jig and fixture design and mechanical work a speciality. OWEN & CRISP, Draughtsmen, 64, Basinghall Street, London, E.C. 2. Tel. No. London Wall 5066. 9650

Diesel Engines, Six Cylinder, Two and Four stroke, 350, 1000, 1300 H.P., excellent condition. Dynamos for above 250 or 500 volts, D.C. Immediate delivery and low price. Two 500 Kw. Parsons Turbine Sets, 250 or 500 volts, D.C., with condensing plant and spare armature. Price £2300. Electrical driven Centrifugal, Ram and other Pumps from 1½ in.-10 in. outlet. JEMMINGS, 9743 West Wells, Newcastle-on-Tyne.

Royles Limited, ENGINEERS, IRLAM, MANCHESTER. FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, } ROWE'S PATENTS. Merrill's Patent TWIN STRAINERS for Pump Suctions. SYPHONIA STEAM TRAPS, REDUCING VALVES High-class GUNMETAL STEAM FITTINGS. WATER SOFTENING and FILTERING. 5732

YARROW & CO. (1922), LTD., GLASGOW.

LAND AND MARINE

YARROW BOILERS. 819

Matthew Paul & Co., Ltd. LEVENFORD WORKS, Dumbarton. 763 See Full Page Advt., page 62, Sept. 15.

Forgings.

Walter Somers, Limited, HALESOWEN. 7116

Taylor & Challen Presses For Sheet Metal Work. Coinage, Cartridges, and Gunpowder. FOUNDRY, WORKS, and SHOWROOMS: BIRMINGHAM. See Illustrated Advt. alternate weeks.

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS. Forgings, Castings, Bars, Sheets, Wire, Tubes. THE DELTA METAL CO., LTD., 631 E. GREENWICH, LONDON, S.E. 10 (& at Birmingham)

Railway Switches and Crossings.

T. SUMMERSON & SONS, LIMITED, DARLINGTON. 609

ON ADMIRALTY LIST.

John Kirkaldy, Ltd., London Office: 101, LEADENHALL ST., E.C.3. Works: BURNT MILL, near HARLOW, ESSEX. Makers of Evaporating and Distilling Plants. Refrigerating and Ice Making Machinery. Feed Water Heaters. Evaporators. Fresh Water Distillers. Main Feed Pumps. Combined Circulating and Air Pumps. Auxiliary Surface Condensers. &c. &c. 846

Locomotive Traversers (ELECTRIC). 9663 S. H. HENWOOD & CO., LTD., RHDDISH.

P. & W. MacLellan, Limited, CLUTHA WORKS, GLASGOW. MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION. RAILWAY IRONWORK, BRIDGES, ROOFING, &c. Chief Offices: 129, Trongate, GLASGOW. Od 3547 Registered Offices: Clutha House, 10, Princes St., Westminster, London, S.W. 1.

Centrifugals.

Pott, Cassels & Williamson, MOTHERWELL, SCOTLAND. 9737 See half-page Advertisement page 63, Sept. 1.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by SIR WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshop Act, 1901. Compensation for Damage and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 896

PATENTS AND DESIGNS ACTS, 1907 & 1919.

Notice is Hereby Given that

WILHELM MAUSS, a British subject, of 73, Cullinan Buildings, Simmonds Street, Johannesburg, Transvaal, Province of Union of South Africa, seeks leave to amend the Specification of Letters Patent No. 178709 granted to him for "Improvements in the heat treatment of liquid."

Particulars of the proposed amendment were set forth in the Illustrated Journal (Patents), issued on the 13th September, 1922.

Any person or persons may give notice of Opposition to the Amendment by leaving Patents Form No. 11 at the Patent Office, 25, Southampton Buildings, London, W.C. 2, within one calendar month from the date of the said Journal.

W. TEMPLE FRANKS,
Comptroller-General.
W 316

APPLICATION FOR A LICENCE OF THE BOARD OF TRADE.

Notice is Hereby Given that

in pursuance of the 20th Section of the Companies (Consolidation) Act, 1908, application has been made to the Board of Trade for a Licence directing an Association about to be formed under the name of "THE INSTITUTION OF ENGINEERING INSPECTION" to be registered with Limited Liability without the addition of the word "Limited" to its name.

The objects for which the Association is proposed to be established are:—

To take over such of the assets and liabilities, if any, of an unincorporated association known as "The Technical Inspection Association" as may lawfully be taken over by the Institution.

The other objects of the Association are set out *in extenso* in the Memorandum of Association, a copy of which may be inspected at the Office of BENNET A. KITE, Esq., 2, Dean's Yard, The Sanctuary, Westminster, S.W. 1, Solicitor.

Notice is hereby further given that any person, Company or Corporation objecting to this application may bring such objection before the Board of Trade on or before the 10th day of October next by a letter addressed to the Comptroller of the Companies Department, Board of Trade, Great George Street, London, S.W. 1.

Dated this 20th day of September, 1922.

C. J. WHARTON,
Hon. Secretary.
W 353

Battersea Polytechnic,

LONDON, S.W. 11.

Principal: ROBERT H. PICKARD, D.Sc., F.R.S.

ENGINEERING DEPARTMENT.

Evening Classes suitable for Final B.Sc. (Eng.), A.M.I.C.E., A.M.I.M.E., &c., are held in the following subjects:—

Strength of Materials with Laboratory Testing.
Theory of Structures and Structural Design.
Theory of Machines and Machine Design.
Heat Engines with Laboratory Testing.
Hydraulics with Laboratory Testing.

Students enrolled from September 19th to 22nd.

DAY TECHNICAL COLLEGE.

Full Time Courses in Mechanical, Civil, and Electrical Engineering for B.Sc. (Eng.), Degree, University of London, or College Diploma commence on September 26th. Entrance Examination commences September 19th. Fee: £18 per session. A higher fee will be charged to students not residing in London.

Full particulars of all Classes on application to the PRINCIPAL.
W 187

LONDON COUNTY COUNCIL.

Westminster Technical INSTITUTE,

Vincent Square, S.W. 1.

Principal—J. STUART KER, B.Sc., A.M.Inst.C.E.

SESSION 1922-23.

CIVIL ENGINEERING.

Evening Sessional Courses to give systematic instruction to Civil Engineers in STRUCTURAL ENGINEERING, REINFORCED CONCRETE DESIGN, SURVEYING AND LEVELLING, HYDRAULICS, SPECIFICATIONS, QUANTITIES AND ESTIMATES, ENGINEERING MATHEMATICS, etc., will begin on 25th September, 1922. Students should enrol during the preceding week.

In addition, SPECIAL ADVANCED SESSIONAL COURSES, intended for those well grounded in the principles of STRUCTURAL DESIGN, have been arranged as under:—

STRUCTURAL ENGINEERING (HIGHER STRUCTURES),
DESIGN OF STEEL FRAME BUILDINGS,
REINFORCED CONCRETE DESIGN.

Full particulars of the courses, fees, etc., are given in the prospectus, which may be obtained on application to the Principal at the Institute.

JAMES BIRD,
Clerk of the London County Council,
W 206

Technical College, BRADFORD.

DAY COURSES.

FULL-TIME (Day) COURSES, extending over three or four years, and leading to the Diploma of the College, are arranged in the following departments:—

TEXTILE INDUSTRIES.
CHEMISTRY.
DYEING.
MECHANICAL ENGINEERING.
CIVIL ENGINEERING.
ELECTRICAL ENGINEERING.
BIOLOGY.

Special facilities are available for ADVANCED STUDY and RESEARCH.

Further particulars and prospectuses may be obtained on application to the PRINCIPAL, Technical College, Bradford.
W 301

The University of Sheffield.

SESSION 1922-23.

VICE-CHANCELLOR:
SIR HENRY HADOW, C.B.E., M.A., D.Mus.

DEPARTMENTS OF MECHANICAL, ELECTRICAL AND CIVIL ENGINEERING, METALLURGY, MINING, FUEL TECHNOLOGY AND GLASS TECHNOLOGY.

PROFESSORS.

Mechanical Engineering—W. RIPPER, C.B., D.Eng., D.Sc., M.Inst.C.E.
Metallurgy—C. H. DESCH, D.Sc., Ph.D., F.I.C.
Civil Engineering—J. HUBBARD, F.R.C.Sc.I., M.Eng., Assoc.M.Inst.C.E.
Mining—D. BAY, B.Sc., Assoc.M.Inst.C.E.
Fuel Technology—R. V. WHEELER, D.Sc., F.I.C.
Glass Technology—W. E. S. TURNER, O.B.E., D.Sc., F.Inst.P.
Chemistry—W. P. WYNNE, D.Sc., F.R.S., F.I.C.
Physics—S. R. MILNER, D.Sc., F.R.S., F.Inst.P.
Geology—W. G. FEARNSIDES, M.A.

Electrical Engineering—H. H. CHAPPEL, M.Eng., M.I.E.E. (Lecturer).
Mathematics—C. A. STEWART, M.A. (Lecturer).

The Courses in the DEPARTMENT OF ENGINEERING extend over three or four years and prepare students to become Mechanical, Electrical, Civil, or Mining Engineers, or specialists in Fuel Technology, or Glass Technology.

The Courses in the DEPARTMENT OF METALLURGY cover a period of three or four years and prepare students for positions of responsibility either (1) in Iron and Steel manufacture; or (2) in the Non-Ferrous Metallurgical Industries.

The LECTURE COURSES in all the Departments are supplemented by Practical Training in Laboratories and Workshops, which are fully equipped for the purpose of advanced scientific teaching, investigation, and research.

Part time courses are arranged for students who desire to take special portions of any of the regular courses.

In Mining Engineering and in certain of the Courses in Mechanical and Electrical Engineering, and in Glass Technology, arrangements are made to enable students, who come to the University from Works or Collieries, to take six months' courses of study at the University and six months' practice at the Works or Colliery each year for a period of four years.

The LECTURE COURSES commence OCTOBER 4th, 1922.

The TECHNICAL LABORATORY COURSES commence SEPTEMBER 26th, 1922.

For further details of the Courses and for particulars of the Degrees, Associateships, Diplomas and Certificates awarded on their successful completion, application should be made to
W 40
W. M. GIBBONS, Registrar.

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 884

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to S/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 875

Inst. C.E. Exams.—Successes

as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 25 years' professional experience.—Address, 7434, Offices of ENGINEERING.

Powering of Vessels.—A

Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 748, Offices of ENGINEERING.

TENDERS.

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 6th October,

Tenders for the Supply of—

1. STEEL MATERIAL.
2. WHEELS and AXLES.

Tenders must be made on forms, copies of which, with Specification, can be obtained at these offices on payment of 10s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices:—The White Mansion,
91, Petty France,
Westminster, S.W. 1.
20th September, 1922. W 362

TO COLLIERIES, ENGINEERS, BOROUGH ENGINEERS, CONTRACTORS, AND OTHERS.

BURNT RED ASHES.

Large Supplies of Burnt Red

ASHES WANTED, from Refuse Destructors, Pits, Collieries, Furnaces, Factories, etc., etc.

Shale is of NO use.

Write, giving particulars of supply and send 1 lb. sample (not more), to BOX 6128, C. D. FLINT, Ltd., 76a, Chancery Lane, London, W.C. 2. W 356

THE BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply

of:—

187 TONS STEEL MATERIAL (Angles, Flats, Round and Plates).

For each copy of the Specification a fee of 10s. will be charged, which fee is not returnable.

Tenders enclosed in sealed envelopes endorsed "Tender for Steel Material," must be delivered at the Company's Offices not later than Twelve Noon on Friday, 29th September, 1922. The Directors do not bind themselves to accept any or the lowest Tender, and reserve the right to divide the order.

By order of the Board,
F. C. FRANKS,
Secretary.

199, Gresham House,
Old Broad Street,
London, E.C. 2.
20th September, 1922. W 354

LONDON & NORTH WESTERN RAILWAY COMPANY.

GENERATING PLANT FOR SALE.

The Railway Company invite

Offers for the following:—

ONE "Yates and Thom" CROSS COMPOUND CORLISS HORIZONTAL ENGINE, direct coupled to a 1200 Kw. "Dick Kerr" Generator.

The Set is suitable for a steam pressure of 160 lbs. per sq. in., and generates A.C. 3-phase, 7500 volts, 25-cycles current when running at 75 revs. per min. High-pressure cylinders 32 in. dia. by 4 ft. 6 in. stroke, and low-pressure cylinders 64 in. dia. by 4 ft. 6 in. stroke, and Indicated Horse Power 2310.

The Set is fitted in the centre of the crank shaft with a large fly wheel alternator, so that it is possible for the engine to be converted for rope driving.

The Set, which is complete with Jet Condensing Plant, Air Pump, and spare parts, etc., is at present in working condition and may be seen running during the next few weeks at Formby Power Station, on the Liverpool and Southport Line. The total weight of this Set is in the neighbourhood of 295 tons.

This Set can be inspected on site, and any further information can be obtained, on application to GEO. HUGHES, Chief Mechanical & Electrical Engineer, L. & N.W. Railway Works, HORWICH, S.O., Lancashire. W 359

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply

of:—

1. BRUSHES.
2. LAMINATED, HELICAL AND VOLUTE SPRINGS.
3. FOUNDRY COKE.
4. CARRIAGE FITTINGS.

Specifications and forms of Tender will be available on Monday, the 25th September, 1922, at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Brushes," or as the case may be must be left with the undersigned not later than Twelve noon, on Tuesday, the 10th October, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10/- for each copy of the Specifications.

Copies of the Drawings may be obtained at the office of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W. 1.
23nd September, 1922. W 361

ABERDEEN CORPORATION WATERWORKS.

EXTENSIONS 1920.

CONTRACT No. 7—NEW AQUEDUCT.

The Town Council of Aberdeen are prepared to receive

Tenders from Competent

Persons willing to enter into a Contract for the TRANSPORTING, LAYING and JOINTING of TWO MILES of 48 in. MILD STEEL PIPING and Ancillary Works, between Gateside of Inchmarlo and Banchory Railway Station.

The Drawings may be inspected, and Specifications, Schedule of Quantities, and Forms of Tender obtained, on and after 21st September, 1922, on application at the Water Engineer's Office, 41½, Union Street, Aberdeen.

For each Specification a deposit of Five Pounds Sterling in cash will be required, which sum will, after a Tender has been accepted, be returned to the Tenderer, provided that he shall have sent in a *bona fide* Tender, based on the Drawings, Specification, and Schedule of Quantities provided, with the Schedule of Quantities fully priced out in detail, and shall not have withdrawn the same.

Tenders on the Forms prescribed and enclosed in securely sealed envelopes endorsed "Tender for New Aqueduct," and addressed to the undersigned, must be delivered not later than 11th October, 1922.

The Town Council do not bind themselves to accept the lowest or any Tender.

GEORGE MITCHELL, M.Inst.C.E.,
Water Engineer.

Water Engineer's Office,
41½, Union Street, Aberdeen.
12th September, 1922. W 293

BENGAL NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the following:—

100 STEEL TYRES.

Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C. 2, on or after 20th September, 1922.

A fee of £1 1s. will be charged for the Specification, which will not be returned.

Tenders must be submitted not later than Noon on Monday, 2nd October, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
T. R. WYNNE,
Managing Director.
W 339

CROYDON UNION.

TO LAUNDRY ENGINEERS, ETC.

The Guardians of the above-named Union invite

Quotations for the following

LAUNDRY MACHINERY required at their Infirmary, viz.:—

(a) One Rotary Foul Washing Machine, of 125 Adult Shirt Capacity.
(b) One 22 in. Hydro; and
(c) One Rotary Washing Machine, of 80 Adult Shirt Capacity.

Inspection of the Laundry by persons desiring to tender may be arranged with the Steward of the Infirmary.

Forms of Specification and other particulars may be obtained of the undersigned and must be returned not later than Monday, October 2nd, 1922.

NORMAN P. WALKER,
Clerk to the Guardians,

Union Offices:—
Mayday Road,
Thornton Heath, Surrey.
19th September, 1922. W 357

TYNE IMPROVEMENT COMMISSION.

DREDGING PLANT.

The Tyne Improvement Commissioners are prepared to receive

Tenders for the Construction

and DELIVERY in the Tyne of the undermentioned:—

ONE NON-PROPELLED CENTRE LADDER BARGE LOADING BUCKET DREDGER.
FOUR SINGLE SCREW STEEL STEAM HOPPER BARGES,
each with a hopper capacity of 800 tons.

Copies of the Form of Tender, Conditions of Contract, General Specification and outline drawings may be obtained from this Office on payment of a deposit of Five Guineas for the Specifications, &c., of the Dredger and the Hopper Barges respectively. The deposit will be returned on receipt of a *bona fide* Tender.

Tenders in sealed envelopes endorsed "Tender for Dredging Plant" must be delivered at the undermentioned Offices, addressed "The Chairman, Dredging and River Works Committee," not later than Noon on Saturday, the 28th of October, 1922.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
J. McDONALD MANSON,
General Manager and Secretary.

Tyne Improvement
Commission Offices,
Bewick Street,
Newcastle-upon-Tyne.
September 20th, 1922. W 363

STATE ELECTRICITY COMMISSION OF VICTORIA.
TENDERS FOR PLANT.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available on and after 21st September, 1922, upon application to:—

AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand, London, W.C. 2.

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M. LIDDELOW,
Secretary.

State Electricity Commission of Victoria,
Melbourne, Victoria,
Australia. W 255

THE RELATION BETWEEN MAGNETIC HYSTERESIS LOSS AND COERCIVITY.

By N. L. ANDERSON, B.Sc., Stud.I.E.E., and T. M. C. LANCE, Stud.I.E.E.

Synopsis of Paper.—The principle here presented asserts that the specific hysteresis loss (W_h) is a function of the product of the coercivity (H_c) into the maximum induction density (B_m), that is:

$$W_h = f(B_m H_c)$$

The value of the function is determined for different magnetic materials, and a general law deduced.

Principle Explained.—It has been pointed out by Professor C. H. Lees and others that a rectangle can be made to represent a hysteresis loop approximately, which assertion is demonstrated in Fig. 1:—

Figures *a*, *b* and *c* are all of the same area, since the altitudes and horizontal widths are the same in each. Or suppose we divide the rectangle *a* into a number of strips, then the parallelogram *b* can be obtained from *a* by sliding the strips over each other and figure *c* can be obtained in a similar manner.

Consider an actual hysteresis loop *d* obtained from experiment. The height is $2B_m$ and the width is $2H_c$ on the horizontal axis. If on this loop we construct a figure of constant width $2H_c$ and of the same altitude as the loop, it is at once clear that the area of the loop is nearly equal to figure *c*, (and consequently to *a*). The actual area of the loop is $\int H\,d\,B$, and the area of the figure *a* is $4 B_m H_c$; now let K be a reduction factor such that

$$K = \frac{\int H\,d\,B}{4\,B_m\,H_c}$$

then since

$$W_h = \frac{1}{4\pi}\int H\,d\,B,$$

we may write

$$K = \frac{4\pi W_h}{4\,B_m\,H_c} = \frac{\pi W_h}{B_m\,H_c},$$

and

$$W_h = \frac{K\,B_m\,H_c}{\pi} \quad . \quad . \quad . \quad (1)$$

The ratio K is found to be nearly constant for any one material, increasing slightly with the maximum induction density (as has been indicated by Dr. W. E. Sumpner*), and when calculated over a large range of B_m is a linear function. The object of the following experiment was to find this relation.

Description of Specimen tested.—The specimen used was in the form of a ring made up of thin stampings of high grade transformer iron. The dimensions of the ring were: External diameter, 6 in.; internal diameter, 5 in.; mean thickness of 15 stampings, 0·496 in. A single layer of thin paper was inserted between each stamping and the next, and the whole ring was wound over with double-lap cotton tape, overwound with 246 turns of primary winding and 50 turns of secondary.

The results were obtained by the three standard methods, viz.: (1) Ewing's method of reversals; (2) step by step; and (3) slow cycle method.* In the table of results these three methods are indicated by the latters E, S S, and S C respectively. The effects of the width of the ring in varying the magnetising force H were neglected. The mean magnetic path was taken as being 5½ in. in diameter.

The ratio K is plotted to the base B_m in Fig. 2, and is apparently a linear function, the relation being expressed by the equation:

$$K = 0{\cdot}66 + 0{\cdot}000032\ B_m)$$

Hence from equation (1):

$$W_h = \frac{1}{\pi}\ (0{\cdot}66 + 0{\cdot}000032\ B_m)\ B_m H_c \text{ ergs/cm}^3\text{/cycle} \quad (2)$$

General Equation for K.—The authors think that a general equation for K can be found which will include most magnetic materials. This statement is supported by Fig. 3, which contains those results from Table I obtained by the slow cycle method, together with results obtained by Mr. F. Stroude, B.Sc., using the same method, and kindly supplied for the purposes of this investigation.† In each case the specimens were in the form of rings wound with primary and secondary coils. From Fig. 3 the equation for K is:

$$K = 0{\cdot}67 + 0{\cdot}000032\ B_m \quad . \quad . \quad (3)$$

It is worthy of notice that this equation can be applied to materials having such widely different hysteresis losses as Stalloy and cast-iron.

As a further check on the work, a large number of figures from other experimenters using the ballistic method were collated and values of K determined for each. These, together with the ballistic results from Table I, are plotted in Fig. 4. The general equation appears to be:

$$K = 0{\cdot}67 + 0.000036\ B_m. \quad . \quad . \quad (4)$$

It is noticed that the variations from the mean line are much greater than in Fig. 3. Reasons for this are that the experimenters worked with: (*a*) Different variations of the ballistic method; (*b*) specimens were made up in the form of rings and rods.

Finally, if we take the mean of equations (3) and (4) we obtain a general equation:

$$K = 0{\cdot}67 + 0{\cdot}000034\ B_m \quad . \quad . \quad (5)$$

This is approximate only, and to find a closer agreement it would be necessary to work out results for a large number of magnetic substances, using for preference the slow cycle method and having all the specimens made up into rings.

Practical Possibilities.—It is seen from the graphs that K is approximately equal to unity for $B_m = 10{,}000$ lines/cm.². That is to say the area of *d* (Fig. 1) is equal to *a*, and thus:

$$W_h = \frac{B_m\,H_c}{\pi}$$

i.e.,

$$W_h = \frac{10{,}000\ H_c}{\pi} = 3180\ H_c \text{ ergs/cm}^3\text{/cycle.}$$

Therefore to obtain the hysteresis loss for $B_m = 10{,}000$ lines/cm² obtain H_c experimentally, and multiply it by 3,180. For any other value of B_m the hysteresis loss can be deduced by the use of Steinmetz's index. As an example, take Stalloy (Steinmetz's index = 1·7). Suppose we find from experiment that $H_c = 2{\cdot}8$ c.g.s. units.

Then

$W_h = 3180 \times 2{\cdot}8 = 8{,}904$ ergs/cm³/cycle for $B_m = 10{,}000$.

and for $B_m = 15{,}000$,

$$W_h = 8904\ \left(\frac{15{,}000}{10{,}000}\right)^{1{\cdot}7}$$

$$= 17{,}700 \text{ ergs/cm}^3\text{/cycle.}$$

The general equation (5) and equation (1) give a ready means of obtaining the specific loss W_h for a given value of B_m from a knowledge of the coercivity. To determine H_c one has only to magnetise the specimen to the maximum induction density B_m, then to reduce and reverse the magnetising current to such a value as to completely demagnetise the specimen. The value of the field strength H_c can then be computed from a knowledge of the dimensions of the specimen and the ampere turns. This short test can be performed by any of the standard methods. The method of reversals provides a good means of obtaining H_c if a Grassot fluxmeter is substituted for the ballistic galvanometer ordinarily used. The advantage of this instrument is that its deflections are proportional to the total flux cutting the search coil and are independent of the time. Thus rapid work is possible.

The test can also be applied to find the loss in an assembled transformer core by using the secondary winding to act as the search coil of the fluxmeter and by using one of the transformer's primary coils to magnetise the core up to B_m. The fluxmeter should be shunted—preferably by an Ayrton-Mather universal shunt.

If we assume Steinmetz's law we can express the coercivity in terms of B_m.

Steinmetz's law states that:

$$W_h = n\,B_m^{\cdot}$$

Fig. 1. RELATION BETWEEN RECTANGLE & HYSTERESIS LOOP.

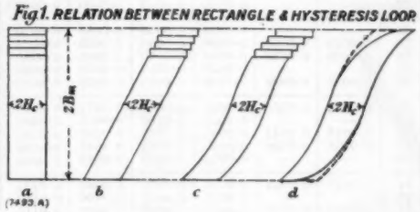


Fig. 2. RESULTS FOR TRANSFORMER IRON.

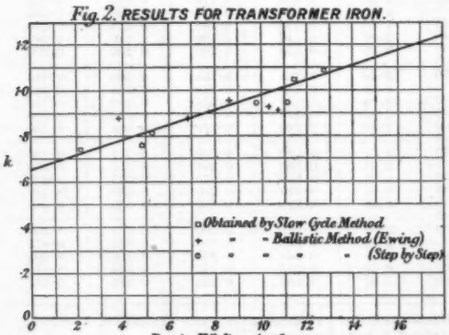


Fig. 3. RESULTS OBTAINED BY SLOW CYCLE METHOD.

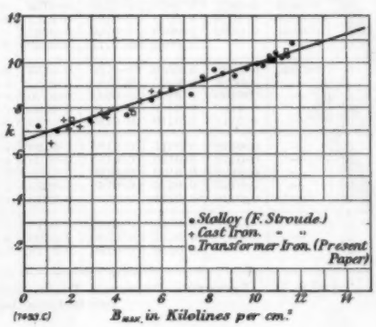


Fig. 4. RESULTS OBTAINED BY BALLISTIC METHODS.

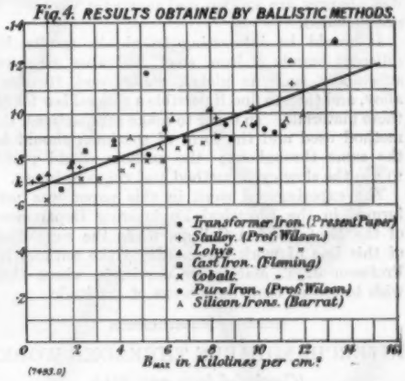

k
• Transformer Iron. (Present Paper)
+ Stalloy. (Prof. Wilson.)
▲ Lohys " "
■ Cast Iron. (Fleming)
× Cobalt. " "
• Pure Iron. (Prof. Wilson.)
A Silicon Irons. (Barrat)
Bmax in Kilolines per cm.²

TABLE I.—*Experimental Results—Best Transformer Iron.*

Method of Obtaining Loops.	Maximum Induction Density B_m (lines/cm²)	Coercivity H_c (in Terms of H).	Hysteresis Loss W_h (ergs/cm³/cycle)	K.
S C	2,050	1·0	488	0·746
E	3,800	1·6	1,690	0·874
S C	4,800	1·9	2,260	0·776
S S	5,280	2·1	2,870	0·815
E	6,870	2·3	4,410	0·878
E	8,600	2·5	6,500	0·950
S S	9,800	2·7	7,950	0·943
E	10,300	2·86	8,620	0·922
E	10,750	2·9	9,000	0·909
S S	11,120	3·0	10,300	0·945
S C	11,420	3·1	11,850	1·05
S C	12,800	3·3	14,620	1·09

* Journal I.E.E., vol. xxxvi, page 465.

* Phys. Soc. Proc., vol. xxiii, page 277.
† Phys. Soc. Proc., vol. xxiv, page 238.

where n and x are constants depending on the material.

From equation (1):

$$W_h = \frac{1}{\pi} K B_m H_c$$

Substituting for W_h:

$$\frac{K B_m H_c}{\pi} = n B_m^x$$

Dividing throughout by B_m:

$$\frac{K H_c}{\pi} = n B_m^{x-1}$$

or

$$H_c = \frac{\pi n}{K} B_m^{x-1} *$$

Thus if we know the value of the constants n, x and K for a material, we can calculate the force to demagnetise it for a given value of the maximum induction density B_m. This might find an application in connection with permanent magnets.

Conclusion.—As previously pointed out, the method used in the experimental determination of the hysteresis loops plays an important part. Even with the same specimen and between the same limits of B_m the areas of loops obtained by ballistic and slow cycle methods differ. The reason for this is that in the slow cycle method the flux changes are uniform and magnetic viscosity or creep is included in the results, whereas in the ballistic method the flux changes are sudden and magnetic viscosity is not included.

It would be interesting to obtain results for different brands of iron, steel, and other magnetic substances such as nickel, cobalt and Heusler's alloy, and then to find if possible a general law for all these materials. In order to make comparisons, the method used and the form of specimen should be the same throughout; the authors would prefer to use the slow cycle method and ring specimens.

The experimental work in this paper was performed in the Electrical Engineering Department of the East London College, while the suggestion of this line of work was made to the authors by Professor J. T. MacGregor-Morris, to whom they wish to record their deep sense of gratitude.

* A relation suggested independently by Prof. C. H. Lees.

INTERCHANGEABLE THREADED WORK.

(*Concluded from page* 321.)

The tolerances for close fits specified in Tables IV and V of the British Engineering Standards Association Report No. 84—1918, are only half those detailed as standard tolerances. To produce screws to these requirements would necessitate the special selection of machine and tools. Even then every screw made would have to be separately inspected and a large proportion of the output would be rejected. Such rejected work would probably fall within the standard limits, however, so would not need necessarily to be scrapped.

It will be seen, therefore, that provided mechanical strength is not decreased too much, it is desirable to work, if possible, to rather coarser tolerances than those specified by the British Engineering Standards Association for the bulk of commercial production. Mr. Sturdee, in his letter published in these columns on June 16, referred to the experiments carried out by the British Engineering Standards Association Screw Thread Committee "in order to find out how much margin one had to play with in setting tolerances." These he summed up as follows: "Speaking from memory, the reduction in strength from full thread engagement to half-thread engagement was of the order of 15 per cent. to 20 per cent." This statement is corroborated by tests made by Mr. Sturdee since he wrote his letter. These tests were made on bolts and nuts made to the ¾ in. B.S.W. form. In the first test, bolts and nuts both within the tolerances specified by British Engineering Standards Association were used. The nuts were made of such a thickness that 3½ and 4 threads were engaged respectively. The 4-thread engagement pair when pulled apart failed by bolt shank fracturing at 10·7 tons. The 3½-thread engagement pair failed by threads bending over at 9·64 tons. Further tests were therefore made with 3¼ threads engaged.

In the second test, the nut was made to British Engineering Standards Association tolerances, but the bolt while of similar form was reduced in diameter till the interference of the bolt and nut threads was only three-quarters of those in the first test. The threads failed at 9·4 tons.

In a third test, similar to the previous one, but with the thread interference reduced to half, the threads failed at 8·15 tons. The sketch, Fig. 6, shows the actual dimensions of the bolts tested. The relative mechanical strengths of the four samples can therefore be deduced as follows:—

TABLE I.—*Effective Diameter Tolerances recommended by Messrs. Alfred Herbert, Limited, for all Screw Threads to English Measurements having a Thread Angle of 55 Deg. or 60 Deg., including B.S.W., B.S.F., U.S.S. and S.A.E. Threads.*

Threads per	B.E.S.A. Tolerances.		Herbert Tolerances.			
	Close Fits.	Standard	Fine F.	Medium M.	Coarse C.	Rough R.
	in.	in.	in.	in.	in.	in.
40	—	—	0·0030	0·0040	0·0050	0·0065
38	—	—	0·0030	0·0045	0·0055	0·0065
36	—	—	0·0035	0·0045	0·0055	0·0066
34	—	—	0·0035	0·0045	0·0055	0·0070
32	—	—	0·0035	0·0045	0·0060	0·0070
30	—	—	0·0035	0·0050	0·0060	0·0070
28	0·0019	0·0038	0·0040	0·0050	0·0065	0·0075
26	0·0020	0·0039	0·0040	0·0050	0·0065	0·0080
24	—	—	0·0040	0·0055	0·0070	0·0080
22	0·0022	0·0043	0·0045	0·0055	0·0070	0·0085
20	0·0023	0·0045	0·0045	0·0060	0·0075	0·0090
19	—	—	0·0045	0·0060	0·0075	0·0090
18	0·0024	0·0047	0·0045	0·0065	0·0080	0·0095
16	0·0025	0·0050	0·0050	0·0065	0·0085	0·0100
15	—	—	0·0050	0·0070	0·0085	0·0105
14	0·0027	0·0053	0·0055	0·0070	0·0090	0·0105
13	—	—	0·0055	0·0075	0·0090	0·0110
12	0·0029	0·0058	0·0060	0·0075	0·0095	0·0115
11	0·0030	0·0060	0·0060	0·0080	0·0100	0·0120
10	0·0032	0·0063	0·0065	0·0085	0·0105	0·0125
9	0·0034	0·0067	0·0065	0·0090	0·0110	0·0135
8	0·0036	0·0071	0·0070	0·0095	0·0120	0·0140
7	0·0038	0·0076	0·0075	0·0100	0·0125	0·0150
6	0·0041	0·0082	0·0080	0·0110	0·0135	0·0165
5½	—	—	0·0085	0·0115	0·0140	0·0170
5	0·0045	0·0089	0·0090	0·0120	0·0150	0·0180
4½	—	0·0094	0·0095	0·0125	0·0155	0·0190
4	—	0·0100	0·0100	0·0135	0·0170	0·0200
3½	—	0·0107	0·0105	0·0140	0·0180	0·0215
3¼	—	0·0111	0·0110	0·0150	0·0185	0·0220
3	—	0·0115	0·0115	0·0155	0·0190	0·0230
2¾	—	0·0118	0·0120	0·0155	0·0195	0·0235
2½	—	0·0121	0·0120	0·0160	0·0200	0·0240
2⅜	—	0·0123	0·0125	0·0165	0·0205	0·0245
2¼	—	0·0126	0·0125	0·0170	0·0210	0·0250
2⅛	—	—	0·0130	0·0175	0·0215	0·0260
2¼	—	—	0·0135	0·0180	0·0220	0·0265
2	—	—	0·0140	0·0190	0·0225	0·0280

TABLE III.—*Effective Diameter Tolerances recommended by Messrs. Alfred Herbert, Limited, for all Metric Threads having a Thread Angle of 53·8 Deg., to 60 Deg. including Sys. Internationale and Lowenherz.*

Pitch in MM.	Herbert Tolerances.			
	Fine F.	Medium M.	Coarse C.	Rough R.
	mm.	mm.	mm.	mm.
0·25	0·050	0·065	0·085	0·100
0·30	0·055	0·075	0·095	0·110
0·35	0·060	0·080	0·100	0·120
0·40	0·065	0·085	0·105	0·130
0·45	0·070	0·090	0·110	0·135
0·50	0·070	0·095	0·120	0·140
0·55	0·075	0·100	0·125	0·150
0·60	0·080	0·105	0·130	0·155
0·70	0·085	0·110	0·140	0·170
0·75	0·090	0·115	0·145	0·175
0·80	0·090	0·120	0·150	0·180
0·85	0·095	0·125	0·155	0·185
0·90	0·095	0·130	0·160	0·190
1·00	0·100	0·135	0·170	0·200
1·10	0·105	0·140	0·175	0·210
1·20	0·110	0·145	0·180	0·220
1·25	0·110	0·150	0·190	0·225
1·30	0·115	0·150	0·190	0·230
1·40	0·120	0·160	0·200	0·240
1·50	0·125	0·165	0·205	0·250
1·60	0·130	0·170	0·210	0·255
1·75	0·135	0·175	0·220	0·265
1·80	0·135	0·180	0·225	0·270
2·00	0·140	0·190	0·240	0·285
2·20	0·150	0·200	0·250	0·300
2·40	0·155	0·205	0·260	0·310
2·50	0·160	0·215	0·265	0·320
2·80	0·170	0·225	0·280	0·340
3·00	0·175	0·235	0·290	0·350
3·20	0·180	0·240	0·300	0·360
3·50	0·190	0·250	0·315	0·380
3·80	0·190	0·255	0·315	0·380
4·00	0·200	0·270	0·335	0·405
4·40	0·210	0·280	0·350	0·425
4·50	0·215	0·285	0·355	0·430
5·00	0·225	0·300	0·375	0·450
5·50	0·235	0·315	0·395	0·475
6·00	0·245	0·330	0·410	0·495
6·50	0·255	0·345	0·430	0·515
7·00	0·265	0·355	0·445	0·535

TABLE II.—EFFECTIVE DIAMETER TOLERANCES RECOMMENDED BY MESSRS. ALFRED HERBERT, LIMITED, FOR BRITISH ASSOCIATION SCREW THREADS.

BOLTS.

Designating No.	Pitch.	Maximum Effective Diameter.	F. Tolerances.		M. Tolerances.		C. Tolerances.		R. Tolerances.	
			Tolerance.	Minimum. Diameter.	Tolerance.	Minimum. Diameter.	Tolerance.	Minimum. Diameter.	Tolerance.	Minimum. Diameter.
	mm.	mm.								
0	1·00	5·400	0·100	5·300	0·135	5·265	0·170	5·230	0·200	5·200
1	0·90	4·760	0·090	4·670	0·120	4·640	0·150	4·610	0·180	4·580
2	0·81	4·215	0·085	4·130	0·115	4·100	0·140	4·075	0·170	4·045
3	0·73	3·660	0·080	3·580	0·105	3·555	0·135	3·525	0·160	3·500
4	0·66	3·205	0·075	3·130	0·100	3·105	0·125	3·080	0·150	3·055
5	0·59	2·845	0·070	2·775	0·095	2·750	0·115	2·730	0·140	2·705
6	0·53	2·480	0·060	2·420	0·080	2·400	0·100	2·380	0·120	2·360
7	0·48	2·210	0·060	2·150	0·080	2·130	0·100	2·110	0·120	2·090
8	0·43	1·940	0·055	1·885	0·075	1·865	0·090	1·850	0·110	1·830
9	0·39	1·665	0·050	1·615	0·065	1·600	0·085	1·580	0·100	1·565
10	0·35	1·490	0·050	1·440	0·065	1·425	0·085	1·405	0·100	1·390
11	0·31	1·315	0·045	1·270	0·060	1·255	0·075	1·240	0·090	1·225
12	0·28	1·130	0·040	1·090	0·055	1·085	0·065	1·065	0·080	1·050
13	0·25	1·050	0·040	1·010	0·055	0·995	0·065	0·985	0·080	0·970
14	0·23	0·860	0·040	0·820	0·055	0·805	0·065	0·795	0·080	0·780
15	0·21	0·775	0·035	0·740	0·050	0·725	0·060	0·715	0·070	0·705

NUTS.

Designating No.	Pitch.	Minimum Effective Diameter.	F. Tolerances.		M. Tolerances.		C. Tolerances.		R. Tolerances.	
			Tolerance.	Maximum Diameter.	Tolerance.	Maximum Diameter.	Tolerance.	Maximum Diameter.	Tolerance.	Maximum Diameter.
	mm.	mm.								
0	1·00	5·415	0·100	5·515	0·135	5·550	0·170	5·585	0·200	5·615
1	0·90	4·775	0·090	4·865	0·120	4·895	0·150	4·925	0·180	4·955
2	0·81	4·230	0·085	4·315	0·115	4·345	0·140	4·370	0·170	4·400
3	0·73	3·675	0·080	3·755	0·105	3·780	0·135	3·810	0·160	3·835
4	0·66	3·220	0·075	3·295	0·100	3·320	0·125	3·345	0·150	3·370
5	0·59	2·860	0·070	2·930	0·095	2·955	0·115	2·975	0·140	3·000
6	0·53	2·495	0·060	2·555	0·080	2·575	0·100	2·595	0·120	2·615
7	0·48	2·225	0·060	2·285	0·080	2·305	0·100	2·325	0·120	2·345
8	0·43	1·955	0·055	2·010	0·075	2·030	0·090	2·045	0·110	2·065
9	0·39	1·680	0·050	1·730	0·065	1·745	0·085	1·765	0·100	1·780
10	0·35	1·505	0·050	1·555	0·065	1·570	0·085	1·590	0·100	1·605
11	0·31	1·330	0·045	1·375	0·060	1·390	0·075	1·405	0·090	1·420
12	0·28	1·145	0·040	1·185	0·055	1·200	0·065	1·210	0·080	1·225
13	0·25	1·065	0·040	1·105	0·055	1·120	0·065	1·130	0·080	1·145
14	0·23	0·875	0·040	0·915	0·055	0·930	0·065	0·940	0·080	0·955
15	0·21	0·790	0·033	0·825	0·050	0·840	0·060	0·850	0·070	0·860

First test:
4 threads engaged—strength 10·7 tons actual.
3½ threads engaged—strength 9·64 tons actual.
3¼ threads engaged—strength 10·17 tons calculated.

Second test:
Strength—9·4 tons—reduction 6·6 per cent.

Third test:
Strength—8·15 tons—reduction 19·9 per cent.

It would appear from this that wider tolerances than those specified by the British Engineering Standards Association can be adopted without sacrificing much of the mechanical strength of the screw. If the standard tolerance is doubled it will only reduce the total flank contact by a very small amount. This can be more clearly seen in the four diagrams, Figs. 7 to 10, in which a thread of 10 to the inch has been drawn 20 times full size with four different degrees of tolerance. Fig. 7 is similar to the standard British Engineering Standards Association tolerances, with the exception that the allowance between largest screw and smallest nut has been drawn to 0·0005 in. instead of 0·002 in. In Fig. 8 the same allowance is observed, while the tolerance has been increased by one-third. In Fig. 9 the allowance is 0·001 in. and the tolerances are two-thirds larger than Fig. 9, while in Fig. 10 the allowance is 0·001 in. (or half the British Engineering Standards Association standard) and the tolerances are double the British Engineering Standards Association standard. By comparing these it will be noted that the coarsest tolerance still gives a good area of flank contact provided the angle is approximately correct.

The four grades of tolerances shown in these diagrams are set out graphically in Fig. 11 for all threads of Whitworth or Sellars' form. These are the tolerances to which Messrs. Alfred Herbert, Limited, work, and which they now recommend for general use. The four grades are specified as F (Fig. 7), M (Fig. 8), C (Fig. 9) and R (Fig. 10) tolerances, to be used as follows:—

F, or fine tolerances, for all high-grade work such as screws for aircraft and for use under excessive vibration.

M, or medium tolerances, for all general high-class work such as motor cars, steam and oil engines, machine tools, &c.

C, or coarse tolerances, for brass work, black bolts and general work where the cost of producing a higher quality cannot be justified.

R, or rough tolerances, for such work as agricultural machines where it is merely necessary for the work to assemble without alteration or adjustment to the screws.

The allowance between the largest screw and smallest nut as recommended by the British Engineering Standards Association is a uniform one of 0·002 in. in all sizes. The reason for this is not quite clear. One-quarter the allowance would be ample provided the gauging system can be relied upon never to pass work outside the limits to which the gauges are set. The only explanation that can be offered is apparently in the fact that at the time this allowance was standardised the only gauging systems accepted were optical projection, measuring machines, ring and solid snap gauges. The two latter only were available for general shop use, and their non-adjustability, coupled with the lack of means of compensation for wear, rendered the fixing of a fairly wide allowance necessary. In drawing up the new series of tolerances, to which they now work, Messrs. Herbert felt that it was better to make use of that 0·002 in. allowance in the working limits, thereby improving the quality of the work without in any way decreasing the working or operating tolerances. If a gauge be provided giving not only an extremely sensitive diametral setting, but also, as in the Wickman adjustable-snap gauge, a means of compensation for wear of the gauge by adjusting the anvils and, in addition, means whereby the true thread form can be maintained by grinding the front of the anvils, there is no need to waste the 0·002 in. allowance. In the tolerances recommended by Messrs. Herbert this has therefore been reduced to 0·0005 in. in the F and M series and to 0·001 in. in the C and R series.

Another very potent reason for the adoption of coarser tolerances is that of cost of manufacture. It is not possible to state any rigid law governing costs according to limits, but it may be taken as roughly correct that manufacturing costs vary inversely with the coarseness of the tolerances used. Thus, to halve the tolerances doubles the cost, while to double the tolerances halves the costs. This may be expressed in a curve of equation $X = \frac{1}{y}$. If the mechanical strength of a screw in its nut be taken as proportional to the flank contact with a 20 per cent. reduction at half-flank contact, we obtain a graph as shown in Fig. 12.

In Tables I, II and III which cover practically every kind of screw thread in general use, the tolerances are calculated to the nearest 0·0005 in. or 0·005 mm. They are given for the effective diameter only for reasons stated previously. It will be seen in Table I, the F tolerances recommended

Fig. 6.

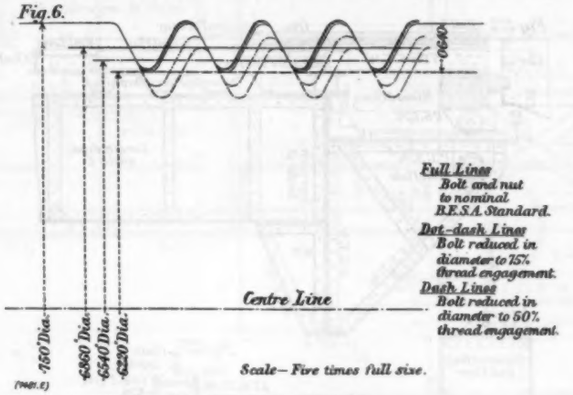


Fig. 7. SCREW AND NUT, 10 THREADS PER INCH, ENLARGED 20 TIMES FULL SIZE. DRAWN TO F TOLERANCES.

Fig. 8. SCREW AND NUT, 10 THREADS PER INCH, ENLARGED 20 TIMES FULL SIZE. DRAWN TO M TOLERANCES.

Fig. 9. SCREW AND NUT, 10 THREADS PER INCH, ENLARGED 20 TIMES FULL SIZE. DRAWN TO C TOLERANCES.

Fig. 10. SCREW AND NUT, 10 THREADS PER INCH, ENLARGED 20 TIMES FULL SIZE. DRAWN TO R TOLERANCES.

Fig. 11. EFFECTIVE DIAMETER TOLERANCES.

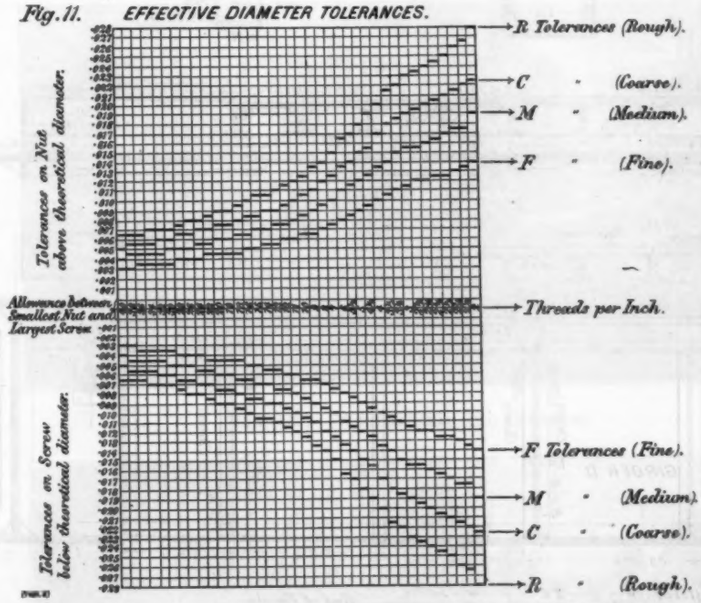
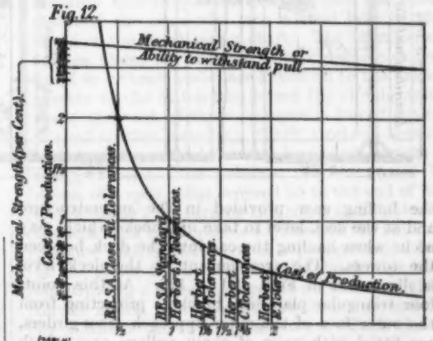


Fig. 12.



by Messrs. Herbert conform very closely to the excellent "standard" tolerances laid down by the British Engineering Standards Association. The same may be said of the F tolerances in Table III, though the British Engineering Standards Association "standard" tolerances are not given there for comparison.

RIACHUELO TRANSPORTER BRIDGE, BUENOS AIRES.

(*Continued from page 290.*)

Buffing Gear.—Before turning to the mechanical equipment it will next be convenient to deal with road and rail level, pairs of longitudinal channels, Figs. 124 and 125, &c., with spaces between them, are riveted to the top surfaces of the pressed steel troughing. Corresponding tee bars are secured to the top of the buffer beam, the stalks of which fit into the spaces between the channels so that the tee bars are free to slide along the channels. Upon the tops of the tee bars, cast steel ribbed plates are secured, extending from the face of the buffer beam to the other end of the tee bars, where they are hinged to a cast steel ramp extension, which also slides upon the tops of the channels and upon the tram rails. Grooves in the cast-steel plates allow for the tram wheel flanges, and the edges of the girders, deadweight buffers, illustrated in Figs. 128 and 129, are provided. These are somewhat similar in action to those already described. The overhead trolley strikes against them at the moment that the transporter car buffers come into play. Each overhead buffer consists of a 12-in. by 9-in. timber block secured to a steel framed carriage suspended from two pairs of wheels and axles running upon the ends of the main trolley tracks. The weight box works up and down between the webs of the end box cross-girders, being suspended by four chains which pass up and round four pulleys mounted on top of the cross-girder. These chains are led round four other pulleys mounted on the

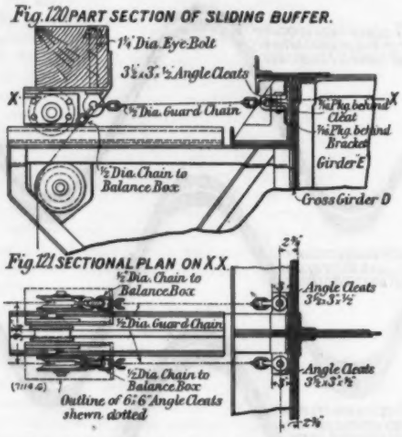
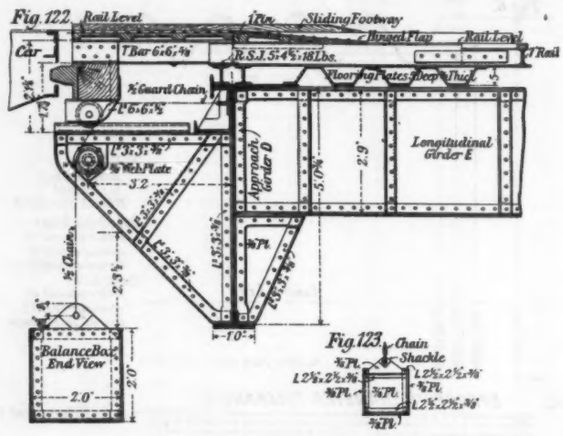


Fig. 120 PART SECTION OF SLIDING BUFFER.
1¼ Dia. Eye Bolt
3½ × 3 × ½ Angle Cleats
X
⅞ Dia. Guard Chain
⅛ Pkg. behind Cleat
⅛ Pkg. behind Bracket
Girder E
½ Dia. Chain to Balance Box
Cross Girder D
Fig. 121 SECTIONAL PLAN ON X X
½ Dia. Chain to Balance Box
½ Dia. Guard Chain
Angle Cleats 3½ × 3 × ½
½ Dia. Chain to Balance Box
Outline of 6 × 6 Angle Cleats shewn dotted



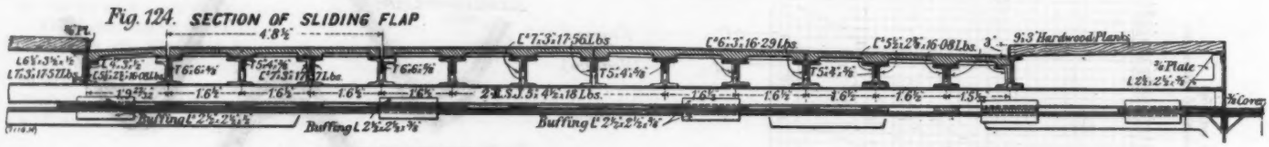
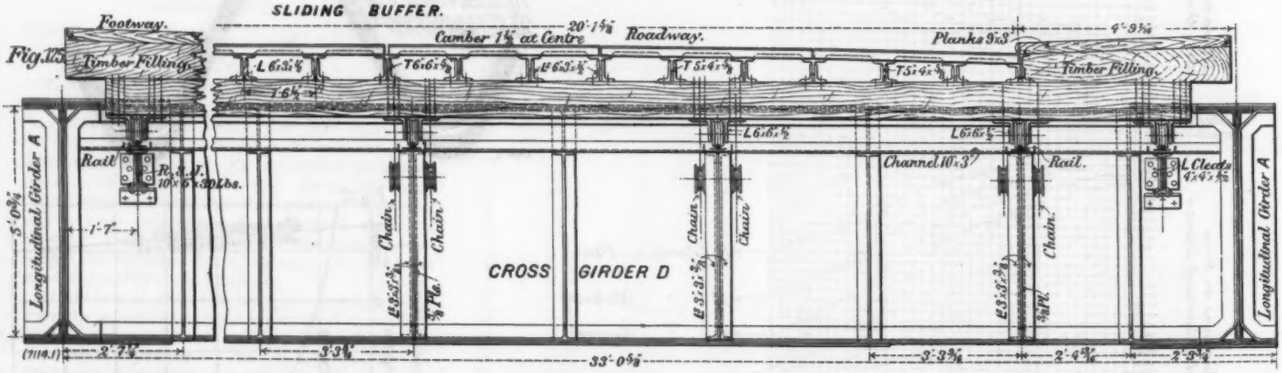
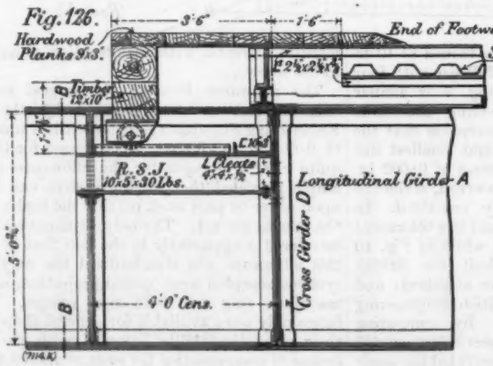
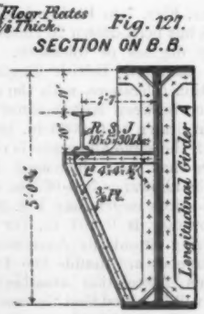


Fig. 124. SECTION OF SLIDING FLAP
⅜ Pl.
4'8½"
L 7 × 3 × 17·56 Lbs
L 6 × 3 × 16·29 Lbs
L 5½ × 2½ × 16·08 Lbs.
3" 9 × 3 Hardwood Planks
⅜ Plate
⅜ Cover
2 R.S.J. 5 × 4½ × 18 Lbs.
Buffing L 2½ × 2½ × ⅜



the buffing gear provided in the superstructure and at the deck level to take up shocks which may occur when hauling the car into the dock between the towers. The arrangement at the deck level is illustrated in Figs. 120 to 127. At this point, four triangular plate-web brackets projecting from the outer face of the outer approach cross-girders, are fitted with pairs of chain pulleys over which pass ½-in. steel chains, which support a weighted steel box. The weight box measures 2 ft. by 2 ft. by 26 ft. 5⅛ in. long. Across the outer edge of the brackets is a transverse hardwood buffer beam mounted upon flanged wheels which run upon short longitudinal rails on the brackets. The upper ends of the ½-in. chains are secured to this buffer beam, horizontal check chains being also provided between the beam and the top of the cross-girder. On the outer face of the buffer beam a spigot casting is bolted, which engages and fits a socket in the buffing plate of the transporter car. When the car runs up against the buffer beam the latter is driven backwards, lifting the weighted box until the momentum of the car is checked. The rebound of the buffer beam is limited by the horizontal check chains. In order to allow for this movement at





plates serve as a continuation of the rails. Thus, however far the buffer moves within the limit of its 2-ft. stroke, no gap occurs in the rails or roadway, Fig. 122. In the case of the footwalks, as shown in Fig. 126, annexed, sliding timber ramps are provided. At the ends of the superstructure main track girders and finally round pulleys mounted upon the running rail joists, after which they are secured to the suspended buffer frame by a pair of eyebolts and nuts. When the trolley frame strikes the buffer face, the buffer carriage is driven along and the chains lift the weighted balance box.

The dead weights for the high and low-level buffers were determined by experiment after erection of the bridge, the weight being made proportional to the relative weight of the overhead trolley and the transporter car and its load, allowing for the fact that the latter has a slight, longitudinal swing. The estimated weights were 4 tons for the overhead buffer and 15 tons for the car buffer. A high level and low level buffer is provided at each end of the bridge.

Machinery.—The machinery, which is accommodated in the engine-house, is electrically operated by a single 45-h.p. motor; a duplicate motor being provided which runs unenergised and idle except in case of emergency. Under ordinary conditions one motor is of ample power to effect a crossing in 1 minute from start to stop. In the first instance, motor pinions with 18 teeth were provided but, after trial, it was found that starting was not readily effected and motor pinions with 10 teeth were substituted. The gear reduction is consequently 10–86–15–64, and with a motor speed of 720 r.p.m. the winding drum speed is 19·6 r.p.m., resulting in a rope speed of about 250 ft. per minute.

The motors are arranged one on each side of the winding drum, Figs. 130 and 131, and the intermediate gears and clutches are in duplicate so that the motors can be run either together or separately. Each motor pinion engages a spur wheel with 86 teeth, keyed on a countershaft at the other end of which is an adjustable slipping clutch with a pinion (15 teeth) which engages the drum spur wheel (64 teeth). The drum is of cast steel, in two equal lengths, which are bolted together, and at each end a spur wheel is bolted to the drum face by six bolts, 1¼ in. diameter. All pinions and spur wheels are of cast steel, with machine-cut teeth. The drum shaft is of steel, 5 in. diameter. The ends of the steel wire hauling rope are formed with eyes laid in recesses against the inner faces of the drum and secured by 1¼ in. diameter pins.

The clutch consists of a cast-iron oiltight case or box keyed on the end of the countershaft, sliding upon the end of the clutch pinion shaft, and containing a set of circular friction plates working in oil. It is seen in the view, Fig. 130. Every alternate cast-iron friction plate is recessed into the clutch case and the remainder into a steel boss or ring keyed on the clutch pinion shaft. The intermediate friction plates are of brass. Six circular plungers, fitted in a thrust plate, are keyed on to the bushed portion of the clutch-case round the clutch pinion shaft, and each of these plungers is forced against the end friction plate by a 720-lb. steel compression spring, giving a total pressure for the six springs of nearly 2 tons. The pressure may be varied by means of a split collar screwed on to the end of the clutch casing; by turning this collar and tightening the lock nuts the clutch is adjusted to the requisite pressure and, in the event of a predetermined load on the motor being exceeded, the clutch slips, thus constituting a safeguard against an undue overload on the motor. The clutches are thrown in and out by means of the striking ear shown. Each clutch-case is in two parts, bolted together, one being cast so as to serve as a brake drum as well.

The clutch brakes are each in two segments, actuated through a toggle joint and lever by a 200 lb. weight which normally keeps the brake applied, the weight being lifted by a solenoid and the brake automatically released when the driving motor is started. This arrangement will be seen in Fig. 130. Adjustment is effected by a union screw on the rod connecting the upper ends of the brake segments. Each brake is capable of applying a retarding pull of 5·12 tons to the hauling rope and bringing the car from full speed to rest, within its own length. In practice only one brake is applied, the other being reserved for emergencies.

A sprocket wheel, fixed to an extension of the winding drum shaft, drives a worm through a chain

Fig. 128. SECTIONAL ELEVATION OF BUFFER.

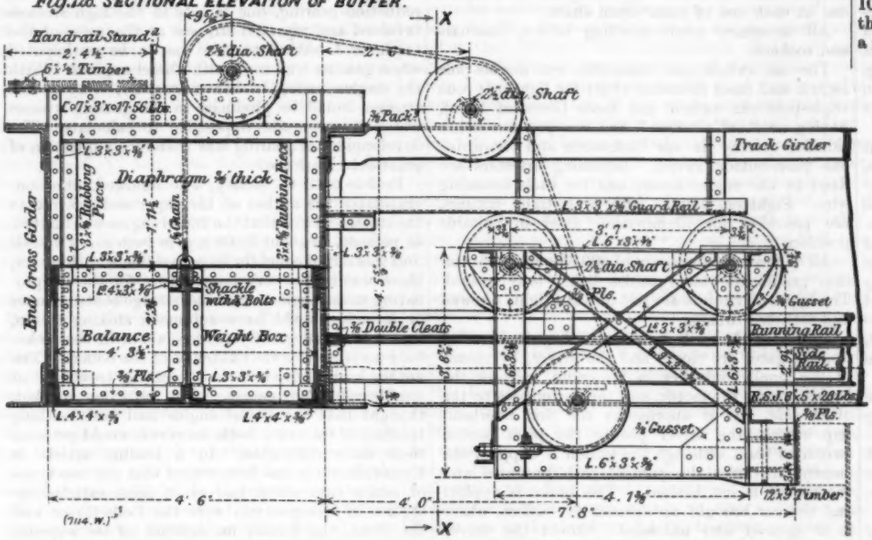
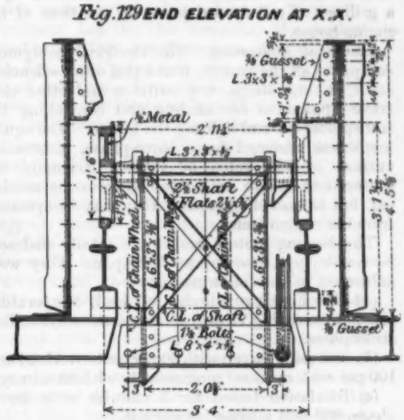


Fig. 129. END ELEVATION AT X.X.



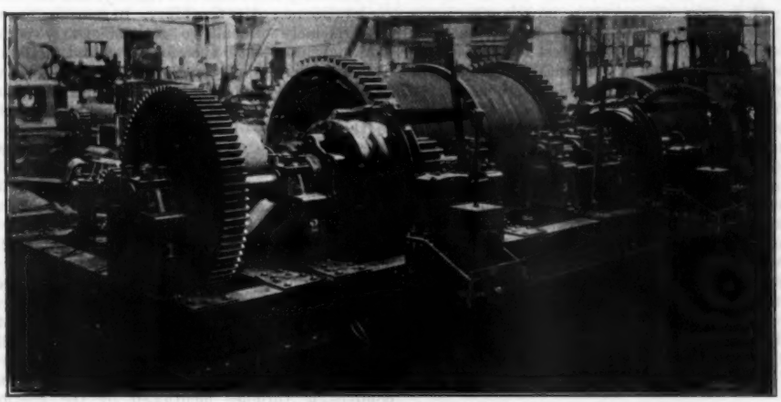


Fig. 130. Winding Gear and Clutches.

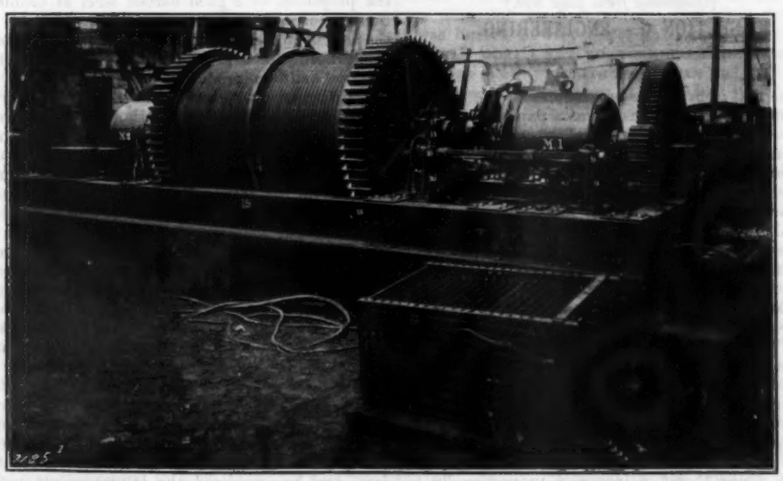


Fig. 131. Winding Gear showing Driving Motor.

and another sprocket wheel on the worm shaft. Travelling nuts on the worm trip switches when the drum has turned through a predetermined number of revolutions in either direction, thereby cutting off the current and allowing the brake to act. Two other limit switches are provided on the overhead trolley, actuated by a striking roller on a bracket fixed beneath one of the track rail joists at each end of the bridge. The motors, gearing, clutches and winding drum are mounted upon a grillage of rolled steel joists on the floor of the engine-house.

Electrical Equipment.—The electrical equipment comprises all the motors, brake and other solenoids, cable, wiring, lamps, trip switches and other electrical appliances for hauling and controlling the transporter car and lighting the bridge. The equipment was designed for a three-phase, alternating current of 220 volts, 50 cycles. Normally the motors and brakes are controlled from the moving car, but in case of emergency they may be operated from the engine house.

The hauling motors are of the totally-enclosed, reversible type, running at 720 r.p.m. They were subjected to the following tests:—

(*a*) One hour's run under full load, temperature rise not exceeding 75 deg. F. above the surrounding atmosphere.

(*b*) Ten minutes run with 50 per cent. overload and 100 per cent. overload momentarily without damage.

(*c*) Insulation tested for 5 minutes with three-phase, 660-volt alternating current.

The two clutch brakes are held on normally by deadweights and released by solenoids. One solenoid is in circuit with the motor, the other is wired independently of the motor and is operated by a movement of the main controller handle. Both solenoids are excited when the motor is started, thus releasing the brakes. The limit switches are wired in circuit with the motor and one solenoid, and when they are tripped the circuit is broken and the solenoid brake is applied. The solenoids, which have special damping action and are fitted with dashpots, exert a pull of 66 lb. through 2 in.

In the vent of a strong following wind, or if for any other reason both brakes should prove insufficient the motor can be reversed.

Four limit switches are provided, two overhead (one at each end of the bridge) and two in the engine-house. The latter, as already explained, are tripped by travelling nuts on a worm actuated through a chain and sprocket wheels by the drum, so that when the drum has completed a predetermined number of revolutions in either direction, one of the switches is tripped and opens the circuit, thereby putting on one of the brakes. The drum limit switches are not under the push button control, and come into operation at the last moment.

A push-button switch is provided in the car cabin to enable the driver to provide a parallel path for the current when the overhead limit switch is tripped and so avoid breaking the circuit or, if he forgets to push the button in time to prevent this, by means of the push button he can release the brake and start the motor again.

The master controller is of the reversible and enclosed type, with contacts to control one solenoid, and complete with resistances for the 45-h.p. motors and also for the solenoids, and designed for controlling the two motors in parallel or either of them singly. The motor not in use is cut out by means of the Salford main switch. The controller is fixed in the ending-house, and is operated by solenoids influenced by a small controller in the car, of the type used in electric lifts. The controller can also be operated by the man in the engine-house, and suitable interlocking apparatus is provided.

The following appliances are mounted on the switchboard:—

One 200-ampere Salford main switch and fuses, ironclad type, which has an "Off position," and two change-over positions, viz., one for running one motor and the other for running both motors.

Two ammeters reading 0 ampere to 240 amperes.

One voltmeter reading 0 volt to 250 bolts.

One double-pole switch fitted with cover and fuses for lighting circuit.

One double-throw car switch, ironclad, with "Off position," and one position either side for driving the car backwards or forwards.

One change-over switch, which cuts out the one or the other car switch.

One master controller.

Two main cut-outs (self-replacing) to work in conjunction with a screw travelling nut device fixed one at each end of main drum shaft.

All necessary interconnecting cables, bus-bars and sockets.

The car switch gear comprises one double-pole switch and fuses (ironclad type) for lighting; one triple-pole car switch and fuses (ironclad type), having an "Off position" and one position either side for driving the car backwards and forwards; one push-button switch. Lightning arresters are fixed in the engine-house, one for each incoming wire. Eighteen lamps, with watertight fittings, are provided for illumination fixed in suitable positions.

All cables and wiring are of 600 Megohm Association grade, the main cables being lead-covered. The trip wire circuits are laid in watertight, screwed and socketed tubing.

Supposing the car to be at its berth: after loading up, the gates are closed and the driver, by means of the small controller in his cabin, releases the brakes, starts the motor, and the car crosses to the other side. As it approaches the first overhead trip switch, the driver presses the push button switch so that, although the switch is tripped, the current traverses the parallel path provided and the circuit is not broken. The brake is applied and the car brought up against the buffers, where it is secured and unloaded. Should the driver forget or, for any other reason, fail to depress the push button, the circuit is broken, the motor stopped and one of the brakes is automatically applied and the car brought to rest before reaching the buffers, unless the driver quickly depresses the button and so releases the brake and starts the motor again.

Five copper conductors with end-tightening screws are suspended from brackets on one of the overhead longitudinal girders on the inner side of the track girders. The current is picked up from these wires by five roller current collectors, fitted on the ends of five arms, each of which is pivoted on the trolley frame. Contact is maintained by a small spring secured at one end of the lever arm by a stud, and at the other end to an arm on the pivot bracket. Alternative positions are provided for the studs, and the vertical rise of the arm is limited by a set screw near its lower end, which bears against a lug on the pivot bracket.

(To be continued.)

THE BRITISH ASSOCIATION.

(*Continued from page* 339.)

SECTION G.—ENGINEERING.

PROPELLING MACHINERY OF THE CARGO CARRIER OF THE FUTURE.

The first item on the programme for the meeting of Tuesday, the 12th inst., was a paper bearing the above title by Mr. James Richardson, B.Sc. The paper, which was read by the author, is reprinted on page 374 of this issue so that we may at once proceed to the discussion on it.

The first speaker in the discussion was Professor Sir J. B. Henderson who, after expressing his appreciation of the paper, remarked that the art of marine propulsion was in a state of transition. The author favoured the Diesel engine, but he (the speaker) considered that this prime mover was only one step in the development of the art and not the final step. On the question of the limit to the horse power produced in a single cylinder, similar cylinders were all equally capable of sustaining a given maximum or mean-effective pressure, but the horse power produced was proportional to the square of the linear dimensions while the weight was proportional to the cube. The weight per horse power therefore increased proportionally to the linear dimensions. He thought the internal-combustion turbine would probably provide a better solution to the problem, but the discovery of some new constructional material was necessary for its development. Materials which would retain their elastic properties at red heat, were already available, if they could be obtained to withstand still higher temperatures the problem of the gas turbine would be practically solved; except perhaps as regards expansion troubles which, however, were less severe with turbines of the impulse type. There were many difficult problems in connection with reduction gearing, due largely to the high stresses involved and repeated stresses at the roots of the teeth, and further trouble was to be anticipated when gearing was used with Diesel engines. With the engine racing in heavy weather, very severe stresses would be produced in the gearing-stresses which it was quite impossible to calculate. The development of gearing was therefore a question of practical experience.

Professor G. G. Stoney, who followed, also congratulated the author on his paper and referred to the statement in it that the Diesel engine was limited, at present, to about 5,000 h.p. in twin screw vessels and was out of court for large fast liners. However, there was still a very large future for the reciprocating steam engine or turbine in cargo boats. Sooner or later we should have automatic stoking at sea, and this would greatly reduce labour in the stokehold and improve the efficiency of the boilers. The author had referred to the "teething troubles" of double-reduction gearing, but he, the speaker, thought that the Diesel engine had had teething troubles of its own; both, however, would get over their early difficulties. In a leading article in ENGINEERING it had been stated that the two types of motor cars which had given most satisfactory service in Mesopotamia were the Rolls-Royce and the Ford, the former on account of its superior workmanship and structural rigidity, and the latter mainly because of its flexibility. In gearing, it would be extremely difficult to get sufficiently perfect workmanship and he therefore preferred flexibility. The combination of torsional flexibility with the axial flexibility of the Macalpine floating frame would probably be found to be the best solution to the problems of double-reduction gearing. In the Ljungström turbine locomotive, recently described in ENGINEERING, torsionally flexible pinions were employed and torsionally flexible wheels were also used in the electric locomotives made by Messrs. Brown, Boveri and Co., in order to reduce stresses. He agreed with the author that electrically-driven auxiliary machinery should be used at sea, since steam-driven auxiliaries were most extravagant. The exhaust from steam auxiliaries was often considerably in excess of requirements for feed heating. A large development in electrically-driven auxiliaries might be looked for in steamers as well as in motor ships. With regard to internal-combustion turbines mentioned by the previous speaker, Professor Stoney said the material required was one which would retain at about 1,500 deg. F. the properties of a good carbon steel at ordinary temperatures. No such material was available at the present time and the internal-combustion turbine would hardly be a practical proposition until that material had been produced.

The discussion was continued by Mr. T. Westgarth, who said he agreed with the author as to the advantages of the use of oil as a fuel at sea. It had immense advantages whether consumed under boilers or used in Diesel engines. In the former application, the saving of labour in the stokehold, the speaker said, was remarkable, and in support of this he might mention the case of a steamer in which he had recently taken a trip. The steamer was propelled by machinery of 5,500 h.p., and steam was supplied by four single-ended boilers having four furnaces each. The whole of the 16 furnaces were attended by one man, who appeared to have hardly anything to do. It was certainly easy and comfortable work, for which it would be possible to obtain the best type of men. He agreed with the author, however, that Diesel machinery was more suitable than steam machinery in most circumstances. He had had much to do with the development of the marine Diesel engine since its early days, and he considered the improvements made had rendered the risks attached to its employment practically nil. Such risks as existed were not more than had to be taken with steam engines, and were certainly not more than with double-reduction geared turbines. With regard to supplies of oil fuel, it was quite true that these could now be obtained anywhere, but the question of cost

had to be considered and the decision to adopt oil fuel, whether for use under boilers or in Diesel engines, was mainly determined by the trade in which the vessel would be engaged. Large passenger liners were in a different category since they must use oil fuel at almost any cost. He agreed with the author that the question of auxiliaries was a most serious one. Here again, the circumstances of each case must be specially considered. In the case of oil carriers, in which it was necessary to employ boilers (usually oil fired) to heat the oil in the tanks, it might be wise to use steam auxiliaries, but no general rule could be laid down in this respect.

Professor F. C. Lea, who followed, said he had not given much attention to the application of the internal-combustion engine to ship propulsion, but he was not quite sure whether the Diesel engine would be the engine of the future for this purpose. There had been a good deal of discussion on the possibilities of the internal-combustion turbine, and at the recent meeting of the Institution of Mechanical Engineers in Paris, Professor Rateau had read a paper on the internal-combustion turbine for aircraft. Very high speeds would, in any case, be necessary, and it was possible that troubles with gearing would be accentuated with this form of prime mover. The future development of the internal-combustion engine depended mainly upon the production of suitable materials. Most of the important engineering developments of the last century had followed developments in materials. It was true that at the present time materials having a certain breaking strength at 800 deg. C. were available, but the breaking strength was low and was largely affected by the time factor. A material which would withstand for short periods a stress of 15 tons per square inch at high temperatures. would fail at a much lower stress if the load were applied continuously for some days. In general, the elastic properties of materials were seriously affected at temperatures higher than 500 deg. C., and this was one of the greatest difficulties. Hopes were, however, entertained in connection with certain nickel alloys, some of which might have the necessary properties at 800 deg. C., but nothing was at present available for use at such temperatures. The author had omitted any reference to another development which might be of importance, viz., the Still engine. Of the total heat produced in the cylinder of an internal-combustion engine, the speaker continued, about one-third appeared in the form of work, one-third escaped with the exhaust, and the remaining third was carried away by the cooling water. The Still engine, however, utilised some of the heat in the exhaust gases. The author had referred to the use of the exhaust for heating the ship and other purposes, and he (the speaker) questioned whether it would be better to use this heat in the engine itself or in connection with the working of the ship. In conclusion, he would have been glad to have heard something of the difficulties encountered in connection with the growth of cast iron, although he thought those difficulties had now been surmounted.

The next speaker, Professor G. W. O. Howe, referred to a statement in the paper to the effect that electrical machinery for marine purposes was only in its infancy and was unreliable. It was difficult to believe that. While it might be true that a few ships fitted with electrical equipment had given considerable trouble, the troubles were due to the fact that the equipment was not suited to the requirements. Such machinery was not specially designed, but was ordinary electrical machinery adapted for marine use. The designing of electrical machinery for this purpose involved no new principles, but the plant required to be of particularly substantial construction. Any electrical firm of good standing would be able to undertake the work and to guarantee the results.

The only other speaker was Mr. J. V. Coonan, whose remarks were heard with difficulty. Mr. Coonan was understood to refer to the advantages of fitting plates of special steels in the cylinder heads of Diesel engines to prevent the gases from coming into direct contact with the cast iron.

Before inviting the author to reply to the points raised in the discussion, the Chairman, Professor T. Hudson Beare, said he wished himself to ask a few questions. He first inquired whether the statement in the paper that vessels of 5,000 h.p. or less constituted 96 per cent. of the total number under construction, referred to all classes of ships or to motor vessels only. In connection with electric propulsion, he understood that there were now under construction in this country a number of vessels for the fruit-carrying trade which would employ this system. The combination of Diesel engines with electric transmission and electrically-driven auxiliaries he regarded as the ideal system, as the engine could then be run at the most suitable speed, as also could be the whole of the auxiliary plant. It must be borne in mind in this connection, however, that the system involved a number of transformations of energy, and that in each transformation a certain amount of energy was lost. He wished to inquire whether it was better to bear these losses or to employ reciprocating engines for driving the auxiliaries. Finally, the utilisation of oil under boilers or in Diesel engines rendered us dependent upon foreign supplies of fuel, which would be a very serious matter in time of war. The Government should be urged to push on with the necessary research work to enable us to utilise our coal resources to the best possible advantage.

Mr. Richardson, who then replied to the discussion, first expressed his appreciation of the reception given to his paper. Professor Henderson, he remarked, had said that the Diesel engine was only a step in the development of prime movers, and whilst this was probably a true estimate, the same remark would apply equally to other systems. The stages in the development of the steam engine had been from the simple to the compound and from the compound to the triple expansion, with a tendency, in larger powers, towards quadruple-expansion engines. The standard for cargo vessels to-day was, however, the triple-expansion steam engine. Less attention was naturally given to this type of machinery, than to that of great passenger liners, although the numbers of ships so fitted, far exceeded those with all other types of propelling machinery. It was the steam reciprocator with which the Diesel oil engine had to compete. He thanked Professor Henderson for explaining the reason for the increase in weight per horse-power with increase in size of engine, as stated in his paper, and expressed his complete agreement with the explanation given, but pointed out that other circumstances came into play, which, to some extent, mitigated the theoretical law. In connection with the internal-combustion turbine, he felt that the question of materials was not by any means the only difficulty, and remarked that if the discovery of suitable materials constituted the one obstacle to be surmounted, an early solution to the whole problem of such turbines might be expected. The economy of the internal-combustion engine was due to the primary fact that the fuel was burned in very dense air, *i.e.*, in highly compressed air, and, if the internal-combustion turbine was to compare in economy, the fuel would require to be consumed in air of equal density. As to how this dense air could be obtained, he observed that reciprocating compressors were the only reasonably economical means of producing it. The Diesel engine itself formed the most efficient air compressor, because it was designed not only to compress air but to withstand combustion. Mechanical gearing with Diesel engines was meeting with a certain amount of success, although, in this connection, the degree of flexibility between the engine and the gearing and between the various units of the gearing, was greatly in excess, in those installations which had come to his attention, of that of standard marine double-reduction geared turbine practice.

Professor Stoney had referred to the use of turbines in cargo vessels, but, in the speaker's opinion, for this class of ship, the future of the Diesel engine was brighter and clearer; the case however, was not so complete for larger ships. He had been greatly interested in the remarks on gearing, but considered that the subject of the choice of suitable materials for the various units of the gearing, which had not been mentioned, was no less important than the question of flexibility. Mr. Westgarth had mentioned the important aspect of the relative prices of oil and coal, and on this point Mr. Richardson remarked that, whilst the comparison of the price of coal and oil in this country was probably as adverse as possible to the Diesel engine, since oil was imported and coal was a home fuel, the balance still favoured the Diesel engine in respect of cost of fuel. The speaker agreed that, in each case, the method of operating auxiliaries must be decided on the merits of the particular case, and whilst he was generally in favour of the all-electric system, he agreed that a combination of steam and electrically-driven auxiliaries might be preferable under certain circumstances. In thanking Professor Lea for his remarks, the author expressed regret that considerations of time would prevent him from going into the question of the growth of cast-iron. In reply to Professor Howe, he stated, that for electrical auxiliaries on board ship, specially-designed machinery was necessary.

The subject of the cracking of cylinder heads, as raised by Mr. Coonan, was dealt with, and Mr. Richardson stated that this was not now such a serious matter as it was some ten years ago. It was quite possible to continue working a Diesel engine with a small crack in the cylinder head. The Germans had fitted steel plates to protect the cast-iron of the cylinder heads, which was probably a development in the right direction. In answer to the chairman, the author said, that the percentages given in his paper referred to all classes of ships, and not to motor ships only, *i.e.*, Diesel engines of 4,800 b.h.p. would be sufficient for the requirements of 96 per cent. in numbers of all the merchant ships building in the world. The Diesel-electric system appeared to have the greatest advantages where the power required for operating the auxiliaries formed a specially large proportion of the whole, and a good example of this type of installation, he said, was a dredger. There was no advantage to be gained from running a Diesel engine at a higher speed, since the piston speed permissible was a constant. He joined issue with the chairman in the matter of foreign fuel and added that the Anglo-Persian Oil Group, as mentioned in the paper, was a purely British concern and was now able to supply a large proportion of the marine oil fuel requirements of this country.

At the conclusion of Mr. Richardson's reply, the chairman remarked that it was hardly necessary to propose a vote of thanks to the author since the meeting had clearly shown its appreciation of the paper.

The Teaching of Mathematics.

On the conclusion of Mr. Richardson's paper the members proceeded to the meeting room of Section L (Educational Science) for a joint discussion with that section on the "Effect of Reformed Methods in Teaching Mathematics." The subject was introduced by three communications, the first of which, by Professor T. P. Nunn, dealt with the principles of formal geometry. This communication put forward the view that the question as to whether there should be a return to a standard sequence of theorems in elementary geometry is of less importance than whether the traditional basis of formal geometry should be retained. Apart from the preliminary doctrine of points, lines and planes, Euclid's system is based upon two assumptions as to the nature of space: Firstly, that it admits of congruent figures and secondly, that it permits one, and only one, line to be drawn through a given point parallel to a given line. In the author's opinion there are strong reasons for adopting, in place of the second assumption, the assumption that space admits of similar figures, leaving the properties of parallel lines to be deduced therefrom, instead of deducing the existence and properties of similar figures from the postulate of parallel lines.

The second communication was by Mr. R. C. Fawdry, and was entitled "The Practical Result of the Reform." It explained that the reforms in mathematical teaching had originated in a revolt against Euclid, followed by a demand from technical colleges that the mathematical equipment of students should be wider in range and of a more practical character. The result was a reconsideration of the purport of mathematics as a part of general education. The postponement of the more academic portions of mathematical training had permitted the early introduction of trigonometry and mechanics, and had enabled many students to

acquire a working knowledge of the calculus before leaving school. The adoption of the newer methods was still far from universal, but progress was assisted by the attitude of the Board of Education, and the Civil Service Commissioners.

The third communication by Professor M. J. M. Hill related to the theory of proportion as expounded in the fifth book of Euclid and, in the absence of the author, an abstract of this paper was read by Professor Nunn. Its main contention was that if the idea of proportion were introduced from first principles, the contents of the fifth book would be of great value to students commencing the study of the calculus.

Invited to speak by Professor Sir R. A. Gregory, the president of Section L, Professor Hudson Beare stated that his experience showed the desirability of keeping the mathematics course for engineering students quite distinct from that for science or arts students. The teacher of mathematics to engineering students, he said, should preferably be an engineer. In the last twenty years he had found a considerable improvement in the standard attained by boys coming from preparatory schools, but he still found a deplorable weakness in arithmetic. Greater accuracy was required, together with a better appreciation of the value of figures. He concluded by remarking that it was not possible to correct at the university the bad effects of inefficient early teaching.

Professor Lea, who followed, advocated the institution of experimental laboratories in the mathematical departments of colleges. He thought that the present tendency was to cover too much ground and not to cover it very thoroughly. It was important, he said, for the student to realise as early as possible, that the degree of accuracy of the final results of calculations depended upon the accuracy of the measurements upon which the calculations were based. The teaching of mathematics must be regarded both as a mental training and as a means for producing a tool for engineers which would enable them to come to definite conclusions with respect to the problems upon which they were engaged. He suggested that teachers should keep this idea in mind.

The next speaker, Professor W. Hewson, thought the older method of teaching mathematics was better for the production of men with logical minds, but was in favour of the reformed methods for the production of a mathematical tool for use in everyday work. Engineering students were now less capable than formerly of following a long train of deductive reasoning, and he attributed this, to some extent, to the less rigid modern methods of teaching mathematics. Mr. C. E. Stromeyer gave some amusing instances of the lack of commonsense in making elementary calculations displayed by some of the candidates for positions as boiler inspectors whom he had examined, but the time available for discussion had elapsed before the speaker had concluded his remarks.

A vote of thanks to the authors of the three communications above referred to, proposed by the chairman, concluded the morning's proceedings as far as the engineering section was concerned. In the afternoon the section visited the Cleveland-street works of the British Oil and Cake Mills, Ltd.

Electrical Ignition Apparatus for Internal-Combustion Engines.

On Wednesday morning, the 13th inst., which was the last day of the session, the first paper taken was one by Dr. E. O. Turner bearing the title given above; this paper we reprint on page 375 of this issue. Since the time allotted to the reading and discussion of the paper was rather short, Dr. Turner merely summarised its chief points, illustrating his remarks by lantern slides of the diagrams reproduced on page 377.

Professor G. W. O. Howe, the first speaker in the discussion on this paper, remarked that the fact that the energy obtained from the explosion was independent of the nature of the spark was now slowly being realised. It had been conclusively proved, he said, that so long as the spark was sufficient to ignite the mixture, the energy of the explosion was the same, so that the various elaborate devices for producing sparks of special quality were practically useless. It did not follow from this, he continued, that theory and practice differed, the apparent difference being due to making certain ideal assumptions in connection with theory and neglecting relevant matters. In a motor-car engine, the spark gap was shunted by a resistance depending upon the amount of moisture deposited, the degree of carbonisation, &c., and the real problem was whether the magneto could supply sufficient energy to produce any spark at all under those conditions. Continuing, the speaker quoted the author to the effect that the two factors most affecting the sparking were the presence of capacity in series with the electrodes and the joint resistance of the leakage paths in parallel with them. The speaker thought, however, that the capacity was not in series with the gap, but in parallel. Such a capacity he added, if very large, might prevent the spark from passing, but, in practice, its effect was usually negligible, leakage being the main factor. He questioned what was the superiority of certain makes of magnetos and remarked that, although the British-made magnetos had been brought to a high state of perfection during the war, many purchasers of motor cars still preferred the Bosch magneto. He thought the superiority of this appliance was not due to any difference in principles or in general design, but was mainly due to small details of manufacture. With regard to the new cobalt steel referred to in the paper, the speaker said he had seen a magneto the magnets of which were made of this material, and had been greatly impressed by its small dimensions. He believed, however, that it was not, at present, an economic proposition to employ this steel, and added that he would be interested to hear from the author as to the prospects of its introduction.

Professor Sir J. B. Henderson, the only other speaker on this paper, said he would like a definition of the term "utility" used in the paper. The indifference of the motor-car engine to the nature of the spark, the speaker thought, was due to turbulence. If the piston were allowed, as Sir Dugald Clerk had done in some of his experiments, to reciprocate several times before the ignition of the charge, so as to allow turbulence to die away, the character of the spark did make an enormous difference. The speaker also inquired why, in the design of induction coils, a closed magnetic circuit was never employed, as this would seem to be a better arrangement. Another point on which the speaker asked for information was the fact that in a petrol engine the work done per stroke was apparently independent of the speed. The curve connecting horse-power and revolutions, he said, was practically a straight line. Considerable throttling must, he thought, take place at high speeds, so that there must be some compensating influence to prevent the horse-power from falling off.

At this point the chairman intimated that the time available for discussion had elapsed, and he therefore called upon the author to reply. In his reply, Dr. Turner thanked Professor Howe for having called attention to the slip in his paper. The capacity referred to, he said, was certainly in parallel with the gap and not in series as he had stated. He also thanked Professor Howe for supporting his statement that the quality of the spark had no effect on the power produced. He could not, however, accept Professor Howe's contention that British magnetos were in any way inferior to those of German manufacture. He considered, in fact, that the former showed many points of superiority in comparison with the latter. It was quite correct to say, however, that the success of the Bosch magneto was due to excellent workmanship in detail. With regard to the use of cobalt steel, the speaker said that with magnetos as at present designed it was not an economic proposition, but its use rendered other forms of construction possible by which much greater energy for a given weight could be obtained. He thought, therefore, that cobalt steel would eventually be employed to the exclusion of tungsten steel. In answer to Professor Henderson, the speaker explained that the term "utility" referred to the conductance in parallel with the plug circuit, this quantity having been employed because it was difficult to say what was going on in the spark circuit itself. With regard to the question as to the possible use of a closed magnetic circuit in induction coils, the speaker explained that an open circuit was employed to give a rapid rate of decay of the flux. If a closed circuit were employed, the flux would die away more slowly, and it would not fall to zero owing to the remanent magnetism of the iron. He thought that progress might be made in the design of the magnetic circuit, but that air gaps would have to be left for the reasons given. He regretted that he could throw no light on the subject of the relationship between the horse-power and speed of a petrol engine as he had not previously considered the point. He did not think, however, that the phenomenon had any connection with the nature of the spark.

The Resolution of Compound Stresses.

The next paper taken was one by Mr. C. E. Stromeyer on the "Resolution of Compound Stresses." This paper describes a method of resolving stresses, devised by the author and based on the fact that resultant stresses produce the same effects (strains) as are produced by the individual stresses they replace. A series of points in a solid is fixed upon, and expressions set up which determine the relative displacements of these points if subjected to a number of stresses acting in various directions. The expressions contain terms which depend only upon the intensities of the stresses and their directions, and not upon the relative positions of the selected points. These terms must be fulfilled by the resultant stresses, and thus formulæ are obtained which determine the intensities and directions of the resultant stresses. For stresses acting parallel to a single plane, the simple rule is evolved that, adopting an arbitrary direction, all the angles which the stresses make with this direction must be doubled, and a polygon of stresses is then constructed with these doubled angles. The end points of this polygon may be regarded as the foci of an ellipse, or of a hyperbola, the major axes of which are equal to the algebraic sum of the stresses. The paper also deals with the resultants of stresses in space, and further explains the application of the method to the measurement of the strains in celluloid made evident by means of polarised light.

Mr. Stromeyer did not read his paper, but briefly explained his method with the aid of blackboard diagrams and, at the conclusion of his remarks, the chairman invited discussion, adding that he thought adequate discussion would be rather difficult as the paper was not easy to follow. Mr. J. S. Wilson, after thanking the author, said that the fact that there was a possibility of simplifying the process of stress resolution was interesting, and he hoped that the material would be made available in some convenient form for study. In thanking the author for his paper, the chairman also expressed the hope that it would be published, and Mr. Stromeyer replied that it was the method he always employed and it appeared quite simple to him.

The Collins' Micro-Indicator.

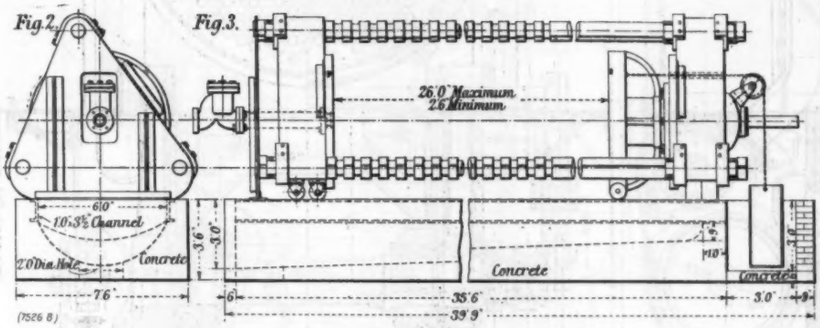
The last item on the programme was a demonstration by Mr. R. S. Whipple of the Collins' micro-indicator for high-speed engines. This instrument, however, was illustrated and fully described on page 716 of our last volume, so that it is unnecessary for us to deal again with its construction and uses. Mr. Whipple first explained that he did not propose so much to demonstrate the use of the instrument, as to describe its design and construction, which he proceeded to do with the aid of a number of lantern slides. Enlarged photographs of diagrams obtained by the instrument were also passed round for inspection.

After Mr. Whipple had concluded, the chairman invited any member who wished to do so to ask questions, and Mr. C. Cooper inquired what was the cause of the irregularities in the expansion curves of the diagrams exhibited. He thought that these could hardly be entirely due to pressure variations in the gas. Mr. Stromeyer suggested that they might be due to the weight of the lever used, and, as an instance of indicator errors, mentioned the case of a marine engine designed to give a certain horse-power with a particular indicator,

HYDRAULIC TESTING MACHINE FOR WELDED STEEL MAINS.

CONSTRUCTED BY MESSRS. RICE AND CO. (LEEDS), LIMITED, ENGINEERS, LEEDS.

FIG. 1.



but unable to develop the total horse-power contracted for because a new and improved form of indicator was employed for the trials. He considered that the steel tape used on the Collins' indicator was a distinct improvement on the cord usually employed, but thought that errors might occur at high speeds. He had detected serious errors in indicator diagrams near the ends of the stroke, and he suggested that this point should be investigated in connection with the Collins' indicator.

In his reply, Mr. Whipple explained that the natural period of vibration of the moving parts of the indicator was less than $\frac{1}{1000}$ second, so that he thought inertia effects would be extremely small. He added that the difficulty due to the cord stretching had been overcome by the use of the steel tape. The criticism of the wavy lines on the diagrams he regarded as sound and he would investigate the cause of it, but too much importance should not be attached to the actual diagrams exhibited, since the engine from which they were taken was not running properly at the time.

The chairman, in thanking Mr. Whipple, remarked that an interesting paper on the effect of the elasticity of indicator cords, &c., had been read at the Institution of Mechanical Engineers some years ago. He added that there was considerable difficulty in indicating internal-combustion motors owing to the very high running speeds employed, and remarked that the mass of the indicator piston itself must produce inertia effects. He then explained that the programme of the section had been completed, and he proposed to bring the meeting to a close.

A vote of thanks to the chairman was then proposed by Professor Henderson, and an acknowledgment of the work of the local secretary, Mr. C. Downs, was made by Professor H. P. Philpot, after which the chairman expressed his appreciation of the courtesies extended to the engineering section by the people of Hull. The meeting of Section G then terminated.

(To be continued.)

HYDRAULIC TESTING MACHINE FOR WELDED STEEL PIPES.

THERE has been considerable development, during recent years, in the use of welded steel water mains, and the pipes of which such mains are composed have increased largely both in diameter and length. The responsibility attached to large steel water mains is often very great, especially when the water supply of a city or the operation of a power-house would be crippled by their failure. It is therefore advisable that the individual lengths of pipe should be tested for strength and soundness, and for this purpose Messrs. Rice and Co. (Leeds), Limited, have recently built the large hydraulic testing machine illustrated in Figs. 1 and 2 above. The machine will admit a pipe up to 6 ft. diameter by 25 ft. in length, and will enable any test pressure up to 300 lb. per square inch on the largest pipe to be applied. This pressure on a 6-ft. diameter pipe subjects the machine to a longitudinal thrust of 378 tons tending to separate the headstocks, in addition to the extra pressure required to make the watertight joints. On pipes less than 6 ft. diameter the test pressure may be more than 300 lb. per square inch, the permissible pressure being in inverse ratio to the cross-sectional area of the pipe.

The machine comprises two triangular heads built up from mild steel plates and sections, welded and riveted together so that an exceedingly strong and stiff structure is obtained. The testing plates which make the joints at the ends of the pipe are of cast iron with grooves machined in them to carry the jointing material. The three bolts which tie the machine together are of square section of mild steel, and a series of recesses are turned in them to carry the stop blocks by which the machine is adjusted to suit various lengths of pipe. Occasionally pipes as small as 18 in. diameter, made of ¼-in. plate, have to be tested, and these and similar small sizes can be dealt with without any distortion or crushing of the pipe, Messrs. Rice and Co. having provided special attachments for this purpose.

The pipe shown under test in Fig. 1 is 48 in. diameter by 16 ft. 6 in. long, made of ¼-in. steel plate, and is a very fine example of machine welding. It is being tested at a pressure of 260 lb. per square inch. The makers, Messrs. Clayton, Son and Co., Limited, of Leeds, make a speciality of similar work, having supplied many miles of welded water mains.

NOTES ON NEW BOOKS.

The development of electrical appliances for all purposes is a subject of interest to everyone from the leaders of thought to the man in the street. Unfortunately little attention is given to the provision of real enlightenment to those who look to the newspapers and popular magazines for information on modern progress; for it rarely happens that those who are responsible for the provision of the news matter of our daily papers have much knowledge of technical affairs, and it is equally seldom that those who have the requisite technical knowledge have either the inclination or the capacity to write for the general public. Mr. Adam Gowans Whyte has all the abilities requisite for this work, and in "*The All-Electric Age*," published by Constable at 7*s.* 6*d.* net, he has written of the romance of electrical developments in a way that will appeal to all. That such a work serves to increase the use of electricity there can be no question, for while it is as interesting as a novel, it provides exact information of what can be done by means of electricity, in the home for cooking, lighting and labour-saving, in industry, power production, traction and communication. There is a wealth of sound advice regarding electric lighting installations and the economical attainment of good illumination. Labour-saving devices in the home, are of paramount importance with the servant problem in such a state as at present, and the descriptions of what can be done with a small outlay for equipment will be welcomed by all domestic users of electricity. Mr. Whyte prophesies the coming of an age when there will be a clearer atmosphere because of the concentration of power production in large economical electrical power stations where perfect combustion of fuel can be assured, and when electric propulsion and lighting will be general throughout the works and homes of the country, and he has done something to bring that day nearer by writing this book.

The production of nitric acid was carried out on a very large scale during the war, and No. 7 of the Technical Records of Explosives Supply, 1915–1918 (H.M. Stationery Office, price 11*s.* post free), on "*The Production of Nitric Acid from Nitric and Sulphuric Acid*," dealing mainly with the operations as conducted at Gretna, will be found one of the most instructive of the series. As in other chemical war departments, the scarcity of experienced staff and workers caused many difficulties and anxieties in the early days, and the noteworthy improvements and scientific control finally realised were only obtained at the cost of much experimenting guided by theoretical considerations. Reports like these may exist in some large works, but they remain private property. The experiments carried out at Queen's Ferry, on working retorts with silica condensers, for the purpose of securing the maximum amount of strong acid and the minimum of weak acid, proved, among other things, that it is advisable to start the distillation with a small fire, and to raise the temperature slowly, to about 105 deg. C. during the first four hours, and to from 120 deg. to 135 deg. during the last hours of the whole period of 15 hours. These figures concern cast-iron retorts, taking about 2 tons of nitre, fired by producer gas. To prevent cracking, the spherical bottom of the retort should not be directly struck by the flame; foundry practice seemed to have more to do with the cracking of the retorts, at first not infrequent, than the

SUPERHEATER, 4-6-2 LOCOMOTIVE FOR THE CHEMINS DE FER DU MIDI.

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Fig. 4.

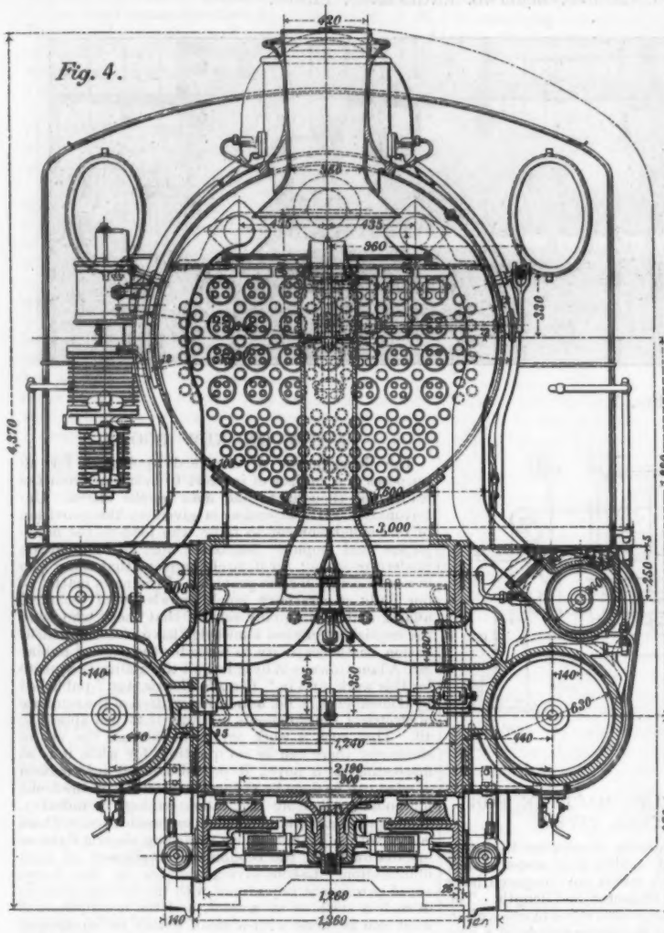
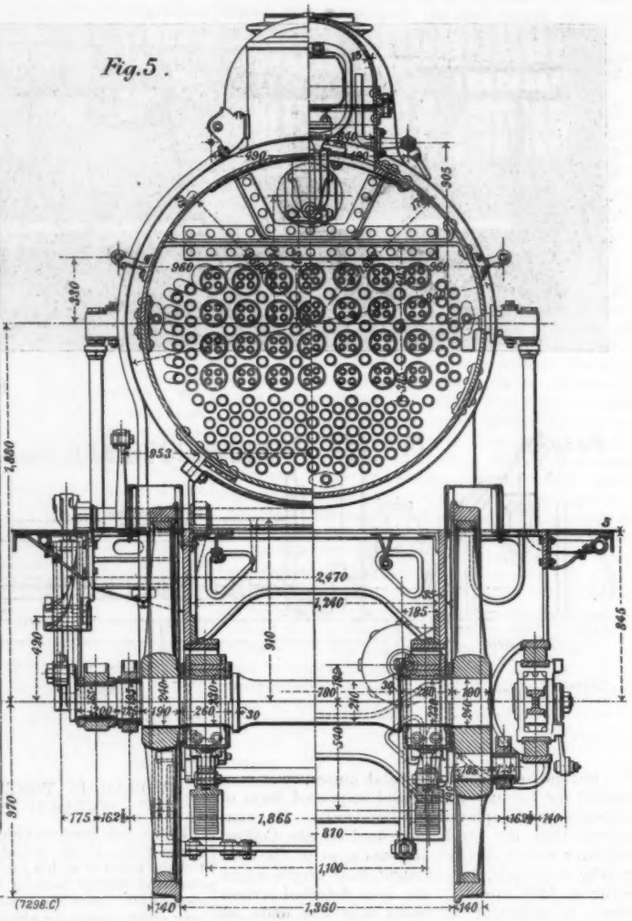


Fig. 5.



composition of the cast-iron. By tapping holes round the crack and screwing on a cast-iron patch, making a joint between the patch and the retort with rust and sal ammoniac, the life of the cracked retorts was prolonged. The report also describes the distillation of spent acid from the manufacture of gun cotton. The spent acid was stored in boiler tanks, 30 ft. by 9 ft., of mild steel and distilled in cast-iron cylinders, 7 ft. deep, 6 ft. 9 in. diameter, of 2-in. wall thickness, provided with a spherical bottom, 3 in. thick; in the still-head, dip pipe and other parts silicon iron proved in the long run, a cheaper material than cast iron. A continuous still or dephlegmating column, was tried, at Queen's Ferry with promising results, but the Armistice put an end to those experiments; in the dephlegmator, the original pottery sections had to be replaced by silicon-iron. The report further gives particulars of the washing of the nitre bags for the purposes of recovering the nitre still left in them, and of making the bags serviceable again. The bags were boiled in tanks, and the solution was sent by cast-iron pressure eggs through the filter-presses (cast-iron and flannel); by adopting a double-circulation and evaporation method, the boilers and eggs were later eliminated, and the whole working cost was reduced to 2·32*d.* per bag, ensuring a profit in a large plant.

In most books dealing with power plant engineering the place of honour is given to boilers and main generating units, the auxiliary machinery being regarded by comparison, as of relatively minor importance. So far as the operator is concerned, however, it is the auxiliary machinery which demands most of his attention, for upon its behaviour the efficiency and reliability of the whole plant mainly depends. This is the view underlying a book on "*Steam Power Plant Auxiliaries and Accessories*," by Terrell Croft (McGraw-Hill Book Company, London, 1922; price 15*s.* net). It is a work of a thoroughly practical nature, describing the construction and action of boiler feed pumps, injectors, centrifugal pumps, feed-heaters, economisers, condensers, steam separators, traps, &c., in a simple and straightforward way. The simpler calculations relating to the various appliances are explained, and the book is particularly well illustrated for a work of its kind. Being an American production, we naturally find horizontal direct-acting pumps, jet condensers and other features of American practice given more prominence than their status in this country would warrant, but this is a small matter, and the book will be found interesting and useful to students and operating engineers. At the end of the chapters are numerous questions relating to the subject matter, the answers to which are given in an Appendix.

In view of the enormous developments that have taken place during the last few years in the use of oil fuel, especially in connection with marine propulsion and industrial heating, we should have expected that a new edition of a book on this subject, produced after the lapse of eleven years, would at least require considerable revision and numerous additions. The only difference we can find, however, after carefully comparing the 1922 edition of "*Liquid Fuel and its Apparatus*," by Mr. W. H. Booth, F.G.S., with the first edition issued in 1911, is the addition of a few lines at the end of two or three chapters, a brief illustrated description of the Gregory burner, and a few notes on colloidal fuel. The notes on the geology of petroleum, economics of liquid fuel, chemistry of petroleum, refractory materials, combustion, &c., with which the early part of the book is taken up, are doubtless as true to-day as they were at the time they were written, but our knowledge of these branches of the subject has certainly been extended during the last decade, and it would have been as well, we think, to call attention to some of the more recent advances. Later chapters deal with the application of oil fuel to marine, locomotive and stationary boilers, and in these chapters numerous systems are illustrated and described in detail. Many, however, are now practically obsolete, and improvements have naturally been effected in most of those still in use. No reference whatever is made to more recently-developed systems, some of which have been very extensively employed. It is unnecessary to enter greatly into detail, but we may draw attention at least to the reproduction in exactly the same form from the first edition of a section headed "The Water-tube Boiler," which devotes a few lines to this subject, mixing it up with a variable locomotive blast pipe cap, and the use of liquid fuel on locomotives on the Arlberg Tunnel. In this case there has been no rectification of what was clearly a bad arrangement in the earlier edition. The chapter on the oil engine shows no appreciation whatever of the valuable developments of recent years, and Sir Dugald Clerk is still spoken of as "Mr." As a revision, the work is very disappointing and the book cannot be said to be a review of modern practice. Had it been rewritten so as to bring former practice into better perspective, and new matter added, it would have been welcome. The price of the book is 10*s.* and it is published by Messrs. Constable.

LOCOMOTIVES FOR THE CHEMINS DE FER DU MIDI.

THE Compagnie des Chemins de Fer du Midi has recently placed in service 20 two-cylinder, superheater, 4–6–2 locomotives, which we illustrate in Figs. 1 to 3, on Plate XXVII, and Figs. 4 to 14 on the present page, and pages 361 and 362. The reason for selecting this type in preference to the four-cylinder compound type already in use on this line is that in the first place, owing to the comparative simplicity of the gear, two-cylinder engines are found to be more reliable and less costly to maintain than four-cylinder compound engines; moreover, owing to the now general use of superheat, the efficiency of two-cylinder

LOCOMOTIVE FOR THE CHEMINS DE FER DU MIDI.

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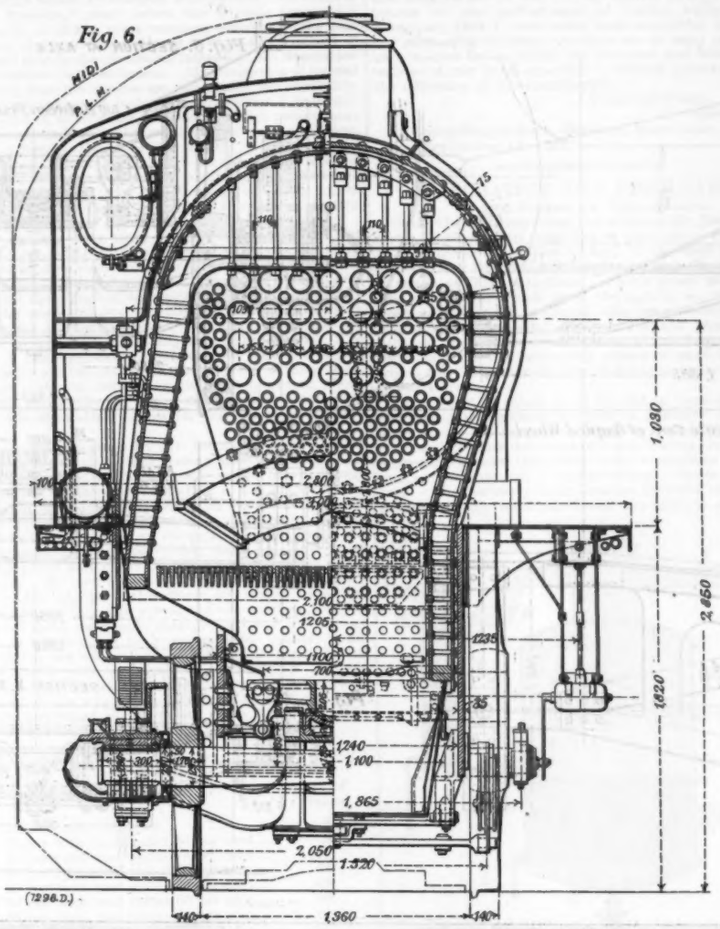
Fig. 6.



non-compound engines approaches quite closely to that of compound engines.

The Midi company commenced testing single expansion with superheat on heavy engines in 1908, and the satisfactory results which these gave led to the designing of the type we now illustrate. Four of these engines were ordered by the company from the Société Alsacienne de Constructions Mécaniques on June 18, 1914, but the war temporarily put a stop to their construction; this was taken up again at the Armistice, when the order was increased to 20 engines. Their characteristic features and principal dimensions are given in the table annexed.

The boiler is generally similar to that of the company's former "Pacific" 4-cylinder compound, superheater type, the grate has the same dimensions and the barrel the same length as in the former type. The two engines, however, differ in the following particulars. The pressure has been lowered from 16 kg. per square cm. (227·5 lb. per square inch) to 13 kg. (184·9 lb. per square inch). The top of the fire-box shell is round as in the Crampton fire-boxes instead of being flat as in the Belpaire. The number of superheating elements has also been raised from $3 \times 8 = 24$ to $4 \times 7 = 28$, and this has enabled the superheating surface to be increased by about 20 per cent., while ratio of the gas passage area through the large tubes to the total passage area through the whole set of tubes is increased from 39·99 per cent. to 46·77 per cent.; this ratio thus approaches 50 per cent., which is recommended in superheating. The number of large tubes has also been increased consequent upon the reduction in that of the small tubes from 145 to 123. The gas passage total area through the tubes and the heating surface have not been influenced to any great degree by this change.

The fire-box is wider at the back than at the front; the grate, which is fitted with a drop section, has an area, as above stated, of 4 sq. m. (43·06 sq. ft.) It is on an incline of 22·5 per cent. The inside fire-box, of copper, is provided with a brick arch. The upper rows of staybolts for the sides of the firebox are of manganese bronze, the lower rows being of copper. The stays are drilled at their two ends. The crown plate is stayed by vertical staybolts hollow throughout their length; those of the two front rows are arranged as expansion stays. The fire-door is hinged horizontally and opens inwards.

The steel barrel is built up of three rings; the transverse seams have double rows of rivets, the longitudinal seams have double butt strap and four rows of rivets. The smoke-box tube plate is of copper. The boiler feed is by two Friedmann injectors. The safety valves are directly loaded, on the Coale system; the water gauge is of the Serveau type. The regulator inside the steam dome is of the Zara type. The adjustable exhaust is annular and the smoke-box is fitted with spark arresters.

The superheater is of the Schmidt type arranged in the boiler tubes. Its elements, 28 in number, consist each of two U-tubes, 36 mm. (1·417 in.) outside diameter mounted in series and extending to a minimum distance of 0·500 m. (19·7 in.) from the back tube plate. The header is of cast-iron; it rests on supports fixed to the smoke-box sides, and is, moreover, suspended at the top by means of hangers.

The link motion, controlled by screw reversing gear on the left side of the footplate, is on the Walschaerts system. The valves are of the piston type with inside admission; they are free on their rods which operate them in the manner similar to flat slide valves. They have grooves fitted with two snap rings of soft cast-iron separated by another cast-iron ring. They are carried by this intermediate ring on cast-iron guides. A special pressure gauge, apart from the boiler pressure gauge, and a pyrometer, both connected to one of the steam chests, show the steam pressure and temperature on its entrance to the cylinders. The pistons are fitted with tail rods. The engine is designed for counter-pressure braking.

The frame is built of deep steel plates, 35 mm. (1·378 in.) thick. There are cross-stays in the front, between the cylinders, at the slide bars, with, in addition, two intermediate stays carried up to the boiler barrel, a stay on which rests a bracket fixed on the front of the lower part of the fire-box casing, the drag-box and the rear headstock. The suspension springs of the three coupled axles are independent; they are underneath the axleboxes and consist of 15 plates, 120 mm. (4·724 in.) in width and 12 mm. (0·472 in.) thick. Their deflection per ton is 6·6 mm. (0·260 in.).

Table of Chief Dimensions.

Cylinders:		
Distance between cylinder centres	2·190 m.	= 7 ft. 2 in.
Diameter of cylinders	0·630 m.	= 2 ft. 1 in.
Stroke	0·650 m.	= 2 ft. 1⅝ in.
Wheels:		
Diameter on tread of bogie wheels	0·900 m.	= 2 ft. 11½ in.
Diameter on tread of coupled wheels	1·940 m.	= 6 ft. 4⅜ in.
Diameter on tread of trailing wheels	1·230 m.	= 4 ft. 0½ in.
Boiler Barrel, Mean inside diameter	1·695 m.	= 5 ft. 7 in.
Length outside tube plates	6·055 m.	= 19 ft. 10 in.
Plate thickness	17·5 mm.	= 0·689 in.
Height of centre above rail level	2·850 m.	= 9 ft. 4 in.
Inside fire-box:		
Height from under foundation ring:		
In front	2·090 m.	= 6 ft. 10 in.
In the rear	1·500 m.	= 4 ft. 11 in.
Length inside:		
At top	2·344 m.	= 7 ft. 8 in.
At bottom	2·745 m.	= 9 ft. 0 in.
Width inside:		
At top	1·380 m.	= 4 ft. 6 in.
At bottom	1·860 m. and 0·965 m.	= 6 ft. 1 in. and 3 ft. 2 in.
Thickness of copper plates:		
Side and back	16 mm.	= 0·630 in.
Tube plate	30 mm.	= 1·181 in.
Firebox shell:		
Length outside	3·050 m.	= 10 ft. 0 in.
Width outside:		
At top	1·760 m.	= 5 ft. 9 in.
At bottom	2·100 m. and 1·205 m.	= 6 ft. 10 in. and 3 ft. 11 in.
Plates, thickness:		
Front	17 mm.	= 0·669 in.
Back	16 mm.	= 0·630 in.
Crown	22 mm.	= 0·866 in.
Sides	15 mm.	= 0·590 in.
Distance of foundation ring above rail level:		
Front	1·050 m.	= 3 ft. 6 in.
Back	1·600 m.	= 5 ft. 3 in.
Boiler tubes:		
Small tubes:		
Number	123	
Outside diameter	57 mm.	= 2·244 in.
Thickness	2·5 mm.	= 0·098 in.
Large tubes:		
Number	28	
Outside diameter:		
Front	133 mm.	= 5·236 in.
Back	119 mm.	= 4·685 in.
Thickness	4 mm.	= 0·157 in.
Superheater tubes:		
Number of return elements	28	
Outside diameter	36 mm.	= 1·417 in.
Thickness	3·5 mm.	= 0·138 in.
Heating Surface:		
Fire-box	15·85 sq. in.	= 171 sq. ft.
Tubes	186·55 sq. m.	= 2,008 sq. ft.
Total	202·40 sq. m.	= 2,179 sq. ft.
Superheating surface, total	73·50 sq. m.	= 791 sq. ft.
Volume; boiler:		
Of water 100 mm. above inside fire-box crown	8·070 cub. m.	= 285 cub. ft.
Of steam	3·620 cub. m.	= 128 cub. ft.
Total	11·690 cub. m.	= 413 cub. ft.
Grate:		
Length inclined	2·800 m.	= 9 ft. 2 in.
Width	1·860 m. and 0·965 m.	= 6 ft. 1 in. and 3 ft. 2 in.
Area	4 sq. m.	= 43·06 sq. ft.
Steam pressure	13 km. per sq. cm.	= 184·90 lb. per sq. in.
Smoke-box:		
Inside diameter	1·730 m.	= 5 ft. 8 in.
Inside length	2·045 m.	= 6 ft. 9 in.
Thickness:		
Tube plate	25 mm.	= 0·984 in.
Front plate	12 mm.	= 0·472 in.
Shell	12 mm.	= 0·472 in.
Frame:		
Width inside frame plates	1·240 m.	= 4 ft. 1 in.
Thickness of frame plates	35 mm.	= 1·378 in.
Total length of engine over buffers	13·595 m.	= 44 ft. 7 in.

Weight:	T.	C.	Q.
Empty	79,500 kg. = 78	4	3
In running order	89,100 kg. = 87	13	3
Available for adhesion	54,000 kg. = 53	3	0
On each bogie axle	10,250 kg. = 10	2	0
On each coupled axle	18,000 kg. = 17	14	1
On the Bissell truck axle	14,600 kg. = 14	7	0

The front bogie truck has inside frames and controlled lateral movement, the control consisting of two laminated springs arranged horizontally on each side of the centre bearing and connected at their ends so that they act together whatever the direction of the movement. The initial load on the control springs is 4,000 kg., and their deflection is 8·3 mm. (0·327 in.)

SUPERHEATER, 4-6-2 LOCOMOTIVE FOR THE CHEMINS DE FER DU MIDI.

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Fig. 7.

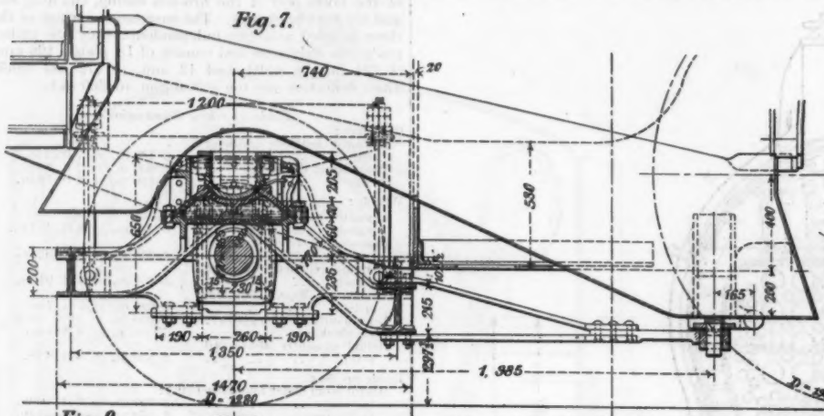


Fig. 9. SECTION AT AXLE

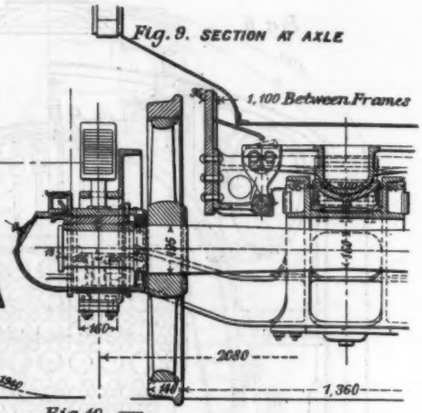


Fig. 8.

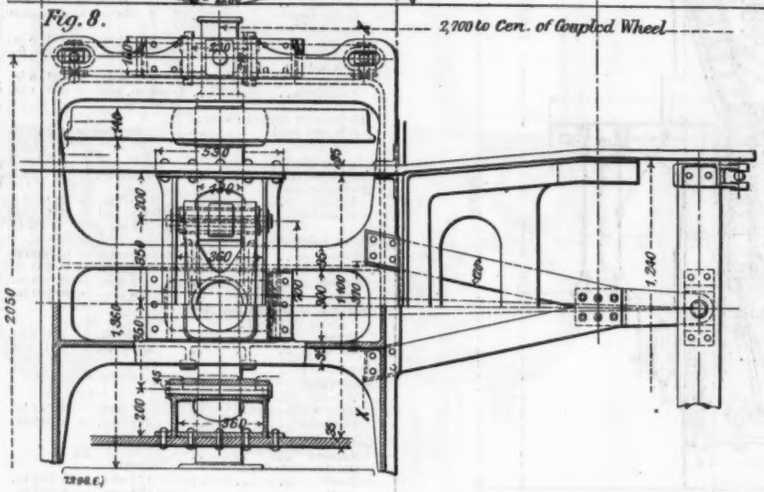


Fig. 10.

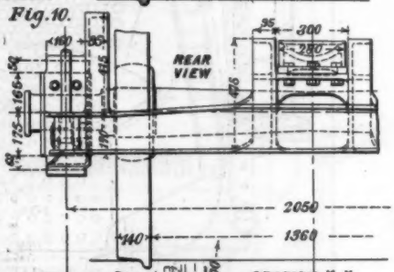


Fig. 11. SECTION X.X.

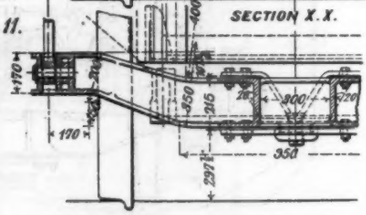


Fig. 12.

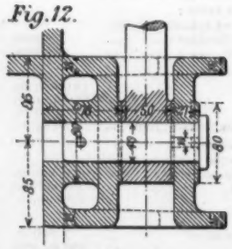
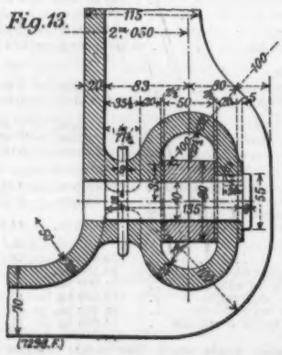


Fig. 13.



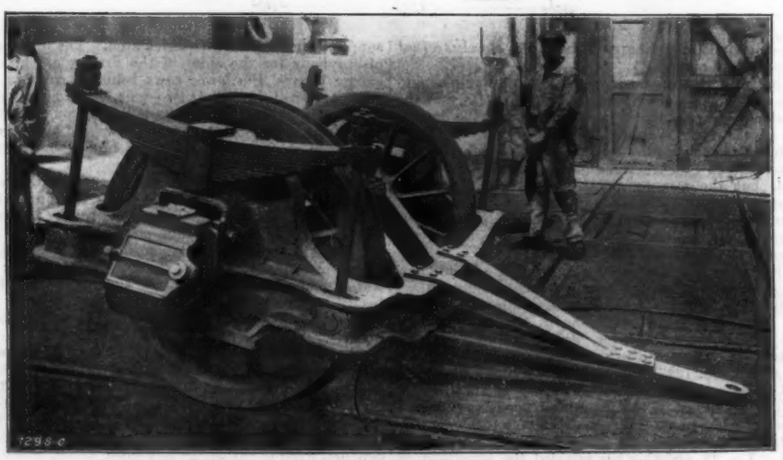


FIG. 14. VIEW OF BISSELL TRUCK.

per ton. The maximum lateral movement of the bogie is 50 mm. (1·968 in.) on either side of the centre. The deflection of the suspension springs is 8 mm. (0·315 in.) per ton.

The single-axle trailing truck, shown in Figs. 1 to 3, is illustrated in detail in Figs. 7 to 14, on the present page; it is fitted with a centre casting in which rests a spherical cup in one piece with a swing bolster. At the two ends of the latter the engine frame is suspended by swing links.

The engine is provided with the Westinghouse brake, acting on the six coupled wheels and the four bogie wheels, the brake blocks on the latter being operated by two cylinders outside the bogie frame plates. There are two sanding gears, one operated by compressed air, of the Gresham type and the other hand operated by screw. The speed indicator is on the Hausshalter system. Lubrication of the cylinders is ensured by a Detroit lubricator having five deliveries supplying oil to the cylinders, the valve chests and to the air pump.

On the line Bordeaux-Cette, on which engines above described have hauled express trains having an average weight of 254 tons; the average coal consumption has been 13·29 kg. per kilometre (47 lb. per mile), a lower consumption than that of the ten-wheel, two-cylinder superheater type previously used on this service.

MARINE STEAM GENERATION.

TO THE EDITOR OF ENGINEERING.

SIR,—I notice from your issue of last week that Engineer-Commander Shaw, R.N., in his paper, "Economic Steam Production with Special Reference to Marine Practice," read before the British Association (Section G, at Hull), gives extracts relating to the performance of steam boiler plants from various papers of mine, and that in the discussion following, Mr. Stromeyer took exception to these figures. Mr. Stromeyer is quoted as stating that my figures are not really representative of the performance of boiler plants, because I had only been called in to investigate cases in which steam users were dissatisfied with the results they were obtaining, and the figures therefore are really worse than the average. Mr. Stromeyer then went on to say that he had tested a number of boiler plants himself, and had prepared statistics from these tests, in which much higher efficiencies were obtained, somewhere in the neighbourhood of 75 per cent.

I am getting very tired of contradicting statements such as those of Mr. Stromeyer, but I trust you will allow me to do so once more with the aid of the wide publicity of your columns. I have been associated since about 1908 with the complete scientific investigation of nearly 500 boiler plants in over 50 different industries in every part of the United Kingdom, and have personally inspected in addition something like 2,000 plants. The figures I have published in about 20 different papers and articles are the average figures for 400 of these tests, together with the detailed individual figures of about 250 tests, and I may say that I am engaged upon a book giving the individual figures for the whole of the 400 plants.

The impression given by Mr. Stromeyer, and various other people as well, is that these plants were in the last stage of decay and inefficiency, the owners of which only came to me in desperation and as a last resort. Now Mr. Stromeyer is absolutely wrong on this point. Nearly all the plants were ordinary, everyday boiler plants, the owers of which were at first quite satisfied with the performance, until we persuaded them to allow us to test the plant and point out the various causes of inefficiency. My own honest opinion, based on the inspection of 2,000 plants, is that these 400 plants tested are actually better than the average of the country, and the owners of them were more enterprising than the average owner in allowing us to investigate the plants at all. That this is the case is also obvious from the following figures giving the net working efficiency of the 400 plants, divided into eight groups, the average net working efficiency of the whole 400 together being 58 per cent., whereas individual plants varied from 32·50 per cent. to 82·21 per cent.

Net Working Efficiency (Boilers, Economisers and Superheaters).

	No. of Plants.
(1) 80 per cent. and over...	2
(2) 75 per cent. and under 80 per cent....	9
(3) 70 per cent. and under 75 per cent....	17
(4) 65 per cent. and under 70 per cent....	58
(5) 60 per cent. and under 65 per cent....	69
(6) 55 per cent. and under 60 per cent....	96
(7) 50 per cent. and under 55 per cent....	80
(8) Below 50 per cent.	69
Total	400

If Mr. Stromeyer is not satisfied that my figures are representative of the boiler plants of this country, then it is up to him to produce 400 boiler tests of his own and let us all have a look at them, and this applies also to various other people who are very free to air opinions which do not seem to be backed by facts. I may state here also that another common objection raised to these tests of mine is that they were carried out only during the war, and are therefore not representative, a statement which is entirely disproved by the dates of the tests, which were actually carried out from 1908 to almost the present time.

Engineer-Commander Shaw need not be much afraid of under-estimating the efficiency of the steam generation plants of this country, whether on land or sea. To anyone who has spent many years in inspecting and testing plants all over the country, it seems to be almost a hopeless proposition to get the average steam user to realise the shocking waste that is going on in every direction for the lack of even the most elementary and commonsense methods, and I estimate that the world to-day is losing over 100,000,000 tons of coal per annum in steam boiler plants alone for lack of these methods, Great Britain being probably no worse than any other country. I may also say that one of the reasons of this depressing state of affairs is the lack of a proper standard method of testing boiler plants, and this question ought to have been tackled by the engineering industry years ago.

Whilst on the subject of the papers at the British Association, perhaps you will allow me to add a comment with regard to mechanical stoking. It is certainly very curious that even to-day hand firing reigns supreme at sea, although some of the very earliest mechanical stokers of seventy or eighty years ago were specifically designed for marine work, and the elder Brunel, for example—presumably in connection with his work on the Great Eastern—patented a marine mechanical stoker consisting essentially of a revolving cylinder inside of which coal was burned. I was also very interested to note that several speakers gave as one of the reasons of the apparent neglect of marine mechanical stokers as being that the results obtained are very little better than hand-firing, and certainly the most ridiculous and exaggerated notions exist to-day amongst a section of steam users on land as regards the efficiency of mechanical stoking.

It seems to me that the saving to be obtained by the application of modern scientific methods of steam generation to marine work is even greater than on land, and that we are in very crying need of really authentic figures for the performance of marine boiler plants. I may say that I have never been successful in getting any steamship company to allow me to carry out a test on a marine boiler plant, and the vast coal bills characteristic of our liners are paid in blissful ignorance as to the efficiency of the consumption.

Yours faithfully,
D. BROWNLIE.

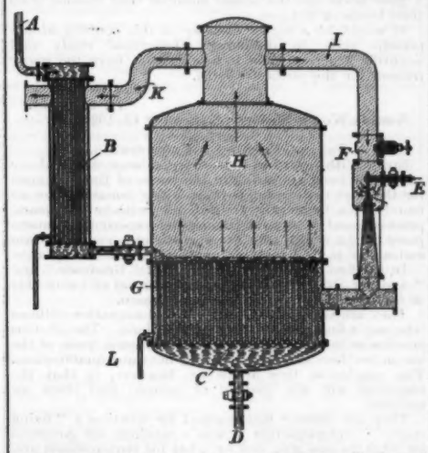
4, Grangethorpe-drive, Burnage, Manchester,
September 18, 1922.

"EVAPORATION AND DISTILLATION."

TO THE EDITOR OF ENGINEERING.

SIR,—Owing to my being out of town, Mr. Liversedge's letter, published on page 306 of your issue of the 8th, only came to my notice to-day. I am very happy to answer Mr. Liversedge's inquiry, and will endeavour to make as small a demand on your space as possible. The evaporator which gives the results set out in my previous letter is indicated diagrammatically in the accompanying sketch. The results are obtained by utilising the reversed heat pump in jet form, and are dependent on the entraining power of that appliance, which has been named the thermo-compressor by the writer's firm.

Live steam is taken in at E, and in passing through the thermo-compressor entrains a quantity of vapour drawn from the evaporator chamber through the pipe I. The final mixture delivered into the heating chamber has a pressure greater than that in the evaporator chamber, and is, therefore, at a correspondingly higher temperature. The necessary conditions for constant evaporation are accordingly established, and the amount of distilled



water produced in the heating chamber will depend primarily on the amount of vapour entrained by the thermo-compressor. If 1 lb. of live steam entrains 4 lb. of vapour, 5 lb. of steam will be delivered to the heating chamber, and the output of the plant will be 4 lb. of distilled water in addition to the pound furnished by the condensation of the live steam used.

It will be noted that part of the vapour produced proceeds to a preheater through K, in which the cold feed is raised to the boiling temperature. This is a necessary arrangement as the vapour entering the heating chamber must approximately equal in weight that produced by ebullition, and as the former has added to it the weight of live steam used, the difference must be utilised in some such manner as indicated or be allowed to escape to the atmosphere.

I have endeavoured to show as shortly as possible how the results quoted in my former letter are obtained, and feel sure your correspondent will now agree that the "accepted laws of physics" instead of rendering the results impossible actually account for the performance. Further information can be obtained from the columns of ENGINEERING, December 29, 1916, and *Engineer*, May 12, 1922, where the plant is fully described, while an article by T. B. Morley, D.Sc., in the latter journal (July 14, 1922) on "The Heat Pump," will be of special interest to Mr. Liversedge.

Yours faithfully,
JAS. B. MACLEAN.

2, Central Buildings, Westminster, S.W. 1,
September 19, 1922.

"THE RESISTANCE TO FIRE OF CONCRETE."

TO THE EDITOR OF ENGINEERING.

SIR,—During the discussion following our paper in Section G of the British Association, Dr. Owens drew attention to the increase in strength of cement mortar by heating to a temperature of 100 deg. C. (Fig. 10 of our paper) and asked the authors if they thought the increase was due to a physical change only. Unfortunately time prevented us from replying to this question. We shall be glad if you will allow us, therefore, to do so in your columns. The effect of temperature up to a certain point appears to have the same effect as ageing and may therefore be due to obscure chemical changes taking place in the material; the change referred to in the question is probably physical rather than chemical. Up to 100 deg. C., as shown in Fig. 2, expansion takes place in the material, but just beyond 100 deg. C. a considerable contraction takes place. Also, as shown in Figs. 7 and 8 of our paper, a considerable percentage of water is driven off at about 100 deg. C. The ordinary ageing of cement can take place under water and therefore the strengthening in the ordinary way is not due to the evaporation of water. Further, if the cement mortar is heated in boiling water it is apparently not strengthened in the same way that it is strengthened when heated in a drying oven. The increase in strength shown in Fig. 10 would appear therefore to be due either to the contraction that takes place at 100 deg. C., or to the evaporation of uncombined water from the specimen. As stones that have absorbed water appear to be strengthened by driving off the absorbed water, it would appear that the increased strength of the cement may be largely due to the change in the hygroscopic condition. The whole problem of change of strength due to heating at temperatures from 0 deg. C. to 100 deg. C. and the effect of these temperatures on rapidity of ageing is being carefully examined.

Yours faithfully,
F. C. LEA.
R. E. STRADLING.

"STRENGTH OF RAILWAY BRIDGES."

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to your recent articles on the above subject and more particularly to the paper recently read before the British Association by Messrs. Cookson and Nicholas, on checking over the calculations for the cross-girder which was tested under traffic I find that the calculated stress of 11 tons per square inch was taken on the gross section of the beam, but that the stress calculated on a section with the bottom rivet hole subtracted (taken as ¾ in. diameter) works out at 13·2 tons per square inch.

The comparison with the extensometer tests by using the gross area of the beam is probably fair, as after all, the extensometer only gives an average stress over the length between the gauge points. The discrepancy in this case between the extensometer stress and that calculated is accounted for by not taking into consideration the distributive effect of the flooring. With the rails, the deep longitudinal boulks, the diagonal decking, the probabilities are that the load on the cross-girder is nearer 11¼ tons than 16 tons (and even then not concentrated under each rail lengthways of the cross-girder) giving a calculated stress on the gross section of 7 tons per square inch, and on the net section of about 3½ tons per square inch.

It seems a pity that records were not taken of the engine standing on the cross-girder as well as passing over it, as then some measure of the distributive effect of the flooring could have been obtained, and an allowance made for "impact."

The conclusion to be drawn from these very interesting experiments is not that the beam theory is wrong, but that the distributive effect of the flooring of railway underbridges should not be ignored.

In a similar manner the apparent discrepancy between the extensometer readings and the calculated stresses could be explained for the main girder reported.

With regard to the laboratory test, the calculated stress has apparently been taken on the net section of the girder. If a mean were taken between that stress and the stress calculated on the gross section it would probably compare very favourably with the extensometer readings.

The probability of serious impact stresses in railway underbridges is remote, observers get the idea with the rush and wind caused by the train, but as a matter of design it is good and sensible practice to use some form of range of stress formula and Messrs. Cookson's and Nicholas's recommendation is timely. Not that the range of stress formulas have anything to do with Wöhler theory, they merely give the desired effect, viz., the metal where it is wanted in rail bearers and cross-girders particularly.

In conclusion I should like to suggest that more information be made available as to what dynamic loads engines deliver to the rails; that with my remarks about the distributive effects of flooring would probably explain a good deal of the discrepancies.

Yours faithfully,
FRANK TIFFANY, B.Sc., Assoc.M.Inst.C.E.

Bridge House, North Rigton, Huby, Leeds,
September 18, 1922.

STRESSES ON RIVETED GIRDERS.

TO THE EDITOR OF ENGINEERING.

SIR,—In the paper of Messrs. Cookson and Nicholas, read before the British Association recently, and given in your issue of the 8th inst., the authors cast doubt upon the expression $\frac{I}{\gamma}$ for the modulus of a section, as a means of arriving at unit stress. In the evidence presented relating to a cross-girder under an assumed load, which load may, due to distribution, have been materially less, the argument is not convincing. There is no need to question the expression named if it be used with discretion. I propose, however, to criticise the way in which it is commonly used.

For many years I have, in dealing with riveted sections, refrained from practising the usual mode of computing the modulus for such cases, *i.e.*, by first determining the moment of inertia in the holed section. My practice is

to compute the modulus for the solid section and, having determined the stress in any part as for no holes, to derive the stress at the holes by multiplying this result by $\frac{\text{gross section of the part}}{\text{net section of the part}}$, the contention being that stress distribution at a section is determined by the solid unpierced part, forming, say, four-fifths of beam length, rather than by the lesser holed part. Treated in this way stresses are derived which may be either greater or less than is given by the usual method, according to the position of the holes, and in bad cases perhaps 10 per cent. different, or even more. Referring to the particular case of the cross-girder submitted to laboratory test, with results displayed in Table III, it appears that the extreme fibre stress would probably be, calculated as above recommended, considerably less than the 10 tons per square inch, estimated by the authors, and the stress in the neighbourhood of the holes through the angles, probably no greater. In this connection it should be understood that localised augmentation of stress at the sides of the holes, as evidenced by Professor Coker's tests and the experimental results of Messrs. Wilson and Haigh, is not considered, but the common assumption of mean stress value only, as is usual with riveted tension members—a practice justified by experience. The ultimate significance of the tests last indicated has yet to be determined.

Yours truly,
September 16, 1922. W. H. THORPE.

"DOUBLE REDUCTION GEARS FOR TURBINES."

TO THE EDITOR OF ENGINEERING.

SIR,—I read with much interest a letter from Mr. W. C. Rowden dealing with the above very interesting and important problem which appeared on page 276 of your issue of September 1. I also read Mr. Wesley Austin's letter on page 306 of your issue of September 8. These gentlemen seem to have unhesitatingly made up their mind as to the cause of failure of reduction gearing pinions. Their keen interest in this problem will no doubt have led them to have made adequate inquiries, and thus put them in the position individually to answer the following questions. Will you, Sir, invite these gentlemen to reply in your pages to the following:—

(1) Why does the intensity of noise produced by different sets vary very largely indeed? Further, why in a noisy gearing has the noise been reduced on fitting the spare pinion?

(2) What is the explanation of the lack of satisfactory contacts as shown by the bright worn areas on the teeth and also the unequal distribution of such worn areas?

(3) What is the explanation of the definite examples where lack of alignment is established? As an instance I understand that there are examples where the contact has only been satisfactory over one-fifth of the length of the geared portion of the pinion, and this, after service at sea.

(4) Why are some gear-cutting machines fitted with a creep mechanism and some not?

(5) What are the stresses which these pinions have to withstand under normal and abnormal conditions?

(6) Why does the fracture occurring in a tooth bear a definite relationship to the geometry of the tooth and pinion?

(7) With particular regard to Mr. Wesley Austin's statement concerning the Izod impact value of the steel, is it not a fact established by Dr. Stanton at the National Physical Laboratory and confirmed by other people that variable Izod value is not reflected in the fatigue range?

In the real interest of the ultimate success of double reduction gears, it is necessary that not only the authors of the letters referred to, but the whole of those technical people interested in reduction gears should arrive at a satisfactory reply to the above questions. I invite a definite answer to all the above points, and, along with various other people who are seriously interested in this problem I shall look forward with interest to what Mr. Rowden and Mr. Wesley Austin have to say.

Yours faithfully,
W. H. HATFIELD.

The Brown-Firth Research Laboratories, Princess-street, Sheffield, September 18, 1922.

"THE COMMERCIAL VALUE OF KNOWLEDGE."

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with some interest your leading article on the above subject, and the ensuing correspondence. As the trend of the latter seems to be distinctly discouraging to those who are making efforts in the way of theoretical study, and as judgment is liable to be registered one way or the other by reading two or three letters from unknown correspondents, I venture to add one or two words in the hope that the final judgment on various points raised may be reserved.

While your leading article undoubtedly puts forward many facts which few will dispute, at the same time it appears to include statements of fact on other matters which are open to argument, and generally so to exaggerate certain aspects of the case as to mislead many parents and others who are not well informed on the matter under discussion.

You state, for instance, that "The average engineering employer is a very shrewd man with a fine appreciation of value, whether in men or things." This statement, however, can only be looked upon from a comparative point of view, and it is open to considerable doubt whether the average employer of to-day does know what qualifications his staff ought to possess, in order to meet modern competition.

You also state that knowledge is only of value to the men who possess it, and to nobody else. This seems a very far-fetched statement, and one must know many cases where appointments have been made on account of the knowledge possessed by the applicant, without any reference to his being able to carry it into action beyond opening his mouth, and saying what he knows; and lastly you state, categorically, that the result of a technical training before workshop training is never satisfactory, whereas the cases that prove the contrary must now amount to many thousands.

It is a very old point as to whether the practical work should come before, during or after, book work, and there is no space to go into the various *pros* and *cons* of these alternatives. The main points which should be borne in mind by parents and students are:—

1. That it is the exception to-day for a man without technical education to get very far.

2. There are various ways of obtaining this technical education, and too much importance need not be attached to when and where.

3. That practical experience is absolutely essential for those wishing to take up practical work, which naturally, will include designing.

4. That, generally speaking, the broader the education both technical and practical, the greater will be the possibilities in front of the men.

5. From the last, it must follow that the years of necessary training will probably increase with the advance of knowledge, and that at the present time a man is not likely to be ready for a position of any responsibility till he has had at least ten years experience, including his theoretical work, that is to say, roughly until he has reached the age of 26.

Finally, my advice to those who have taken a theoretical course is not to be discouraged if they do not find an immediate use for what they have learned, as they are pretty certain to find it some day, providing they can get through the present difficult times. Book work will have developed their brain to an extent that they hardly realise, and will have been worth while if they never use the actual material they learned from their books or lectures.

It would be a bigger disaster to this country at the present time to discourage theoretical study and scientific progress, than it would be to have too many trained for the posts available.

Yours, &c.,
H. S. BURN.

Norfolk Works, Sheffield, September 14, 1922.

TO THE EDITOR OF ENGINEERING.

SIR,—With regard to the correspondence on the above which has been appearing in the issues of ENGINEERING for the past two weeks, perhaps a few remarks from an ex-officer, a technically-trained man with twenty years' practical and successful engineering experience in many parts of the world, who has spent over a year in a vain endeavour to find some occupation, may be acceptable.

In the first place it strikes one that "Graduate" and "Another Graduate" fail in the essential of being able to follow evidence to its logical conclusion.

They are two out of about one and a-quarter millions who can't find jobs in this country alone. The obvious conclusion is that there are very few berths (even of the vacancies there are) for which they have any qualification. The conclusion they arrive at, however, is that the employer will not (instead of cannot) find them an opening.

They are further handicapped by wanting a "living wage"; unfortunately a man's earnings are governed by what he can give, not by what his requirements are.

I can assure these gentlemen that over and over again I have had appeals from men who have done most satisfactory work for me in normal times who are now prepared to take any job that is going at any figure, and I have found it impossible to put anything forward for them.

Whilst I am not in entire agreement with "Anti-Professor's" letter, he does raise a very important point when he asks who advised "Graduate" to take up engineering.

For years past the profession has been enormously overcrowded, even during the war with its developments and output of material, there was no shortage of men to do the actual engineering (as apart from mechanical) work, and there is little prospect of things improving so long as we have colleges all over the country engaged in turning out men with engineering diplomas on the mass-production system.

In the days of apprenticeships, matters adjusted themselves to a certain extent, as firms were not able to take many apprentices, and apart from that, having to be at work at 6 a.m. meant doing without social amenities, which kept out many of the prospective candidates.

Now if a technical school has more applications than it has accommodation for, it extends, and points to its having had to extend as a proof of its success, without regard to whether the profession can assimilate the product.

As regards the obligation of the employer to employ ex-service men, as things are at present, their first care is surely to get their works on sound economic bases again, if in doing this they are able to give some preference to the ex-service man to the extent, say, of making an allowance for his being a little "rusty" by not having used his special knowledge for a few years, that is, I think, about all that we can reasonably expect. We certainly cannot expect a firm running at a loss (as so many concerns are doing) to employ men for whom they have nothing to do simply because they spent some time in one of the services. After all, we had compulsory service, and although it may have left loopholes for the "slacker" it has made the position rather different to what it would have been had voluntary service prevailed during the whole period. In the case of many of the younger officers who got safely through the war, they received opportunities for professional training they would never have had in the ordinary course of events, and if they decided that they would like to be engineers, surely it was for them to investigate its prospects before embarking on it, rather than have a grievance at the end of their college training.

Yours faithfully,
September 18, 1922. R. P.

TO THE EDITOR OF ENGINEERING.

SIR,—How can "Another Graduate" expect to get a job if, when I "miss the point," we are told of our "seeming lack of appreciation of the fundamental difficulty underlying the position"? That is the sort of stuff that goes down all right at technical colleges, but it would be enough to get a chap the "sack" anywhere else. We want men who can *do* and *make* things, and not *talk* so much.

Now, I have been hit very hard by the war; and if some of these graduates had come to me for advice, instead of acting on their own three years ago, I should have told them what I said in my previous letter. I know what I am talking about, as I have sent two young fellows to Canada, one to United States and one to Australia. The latter, a "captain," worked as a plumber's mate for one and a half years, and then did some carpentering. I have just received a note from him dated August 10, in which he says: "Thank you very much for sending me out here. It is a healthy life. I am out from daylight till dark; and there is plenty of good money to be had for good work."

In a manner of speaking my heart bleeds for these young graduates who took a wrong course and now ask "How could we do otherwise?" "We chose . . . the acquisition of the knowledge so despised by 'Anti-Professor.'"

Please allow me to say that I do *not* despise knowledge, as "Another Graduate" will see if he reads my first letter again. He chose the wrong kind of knowledge and the wrong way of acquiring it; and now he and his fellow graduates are whining about the result.

Labour is not degrading; but it fairly gives me the hump to find so many of us under the thumb of professors; and I hear the Council of the Civil Engineers now have a professor as secretary. Well, well!

Yours truly,
September 19, 1922. "ANTI-PROFESSOR."

STATES AND ENTITIES: WHAT IS ENERGY?

TO THE EDITOR OF ENGINEERING.

SIR,—I thank "B.Sc." for his note of appreciation of my effort to make things clear; and I thank "An Occasional Reader" also for the opportunity, if you, Sir, will kindly grant me space, to say a few words on some of the points raised by him.

First, allow me to restate my conclusions:—

1. "Energy" *means* ability to do work.
2. There is no such *thing* (entity) as energy.
3. Energy has never done—nor can it ever do—work.
4. Work is done only by bodies—solid, liquid, or attenuated—when in motion of some kind.
5. Matter, in its various forms and states (conditions), is that which affects our senses—it is the only entity known to us.

"An Occasional Reader" says "In the wide realm of physics, energy has been shown to possess mass"; but has it? What is probable is that matter in some form, having "got a move on," did work of some kind, and that "energy" got the credit for it! Nobody can deny that matter has mass; but it is *matter* that does the work, when matter is in motion—and at no other time. I certainly was very careful *not* to say "energy *is* ability to do work," and I object to the phrase "energy *has* ability to do work." This is not word-splitting; it is an honest attempt to be precise; for what I said and what I wish to repeat was, "Energy *means* ability to do work."

One word about Einstein, to whom we should all be grateful for recalling our attention to relativity. If the confirmation of his theory depends on photographs taken at the time of and after the eclipse alluded to by "Occasional Reader," we must take into account the possibility of there sometimes being more difference between two plates forming a series of photographs than was found between two of the set taken at the eclipse expedition. Whatever may be proved ultimately, why have any doubt about the effect of a huge mass like the Sun on the refractive index in its atmosphere or other medium?

Faithfully yours,
"A CONSTANT READER SINCE 1870."
September 19, 1922.

"INGEGNERIA."—The National Association of Italian Engineers has decided to publish a monthly periodical entitled *Ingegneria*. The first number, for last July, contains interesting articles on engineering schools, on the road question in Italy, power stations, motor tests, &c., also letters to the editor. The publisher is Mr. Ulrico Hoepli, and the representatives in this country are the firm David Nutt (A. G. Berry), 212, Shaftesbury-avenue, W.C. 2. The price of subscription for foreign countries is 45 lire.

CLEVELAND AUTOMATIC SCREW MACHINES.—Messrs. Alfred Herbert, Limited, Coventry, inform us that agreements have been signed between the Cleveland Automatic Machine Company, of Cleveland, Ohio, U.S.A., and themselves whereby they become the authorised sole selling agents for the well-known Cleveland automatic screw and forming machines made by this firm. These machines handle all sizes of bar material from ¼ in. to 7¾ in. dia., also forgings, castings and blanks of similar dimensions.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Failure of the mayors of the armament-making centres to obtain from the Government any promise that the placing of contracts for the materials required for the two new battleships will be expedited, has caused a good deal of dissatisfaction locally. In the absence of such work unemployment must continue to be severe throughout the winter. On general commercial account order books are not filling with anything like the rapidity that could be wished, but the forward movement grows steadily stronger. A much improved business is being done in basic iron. Furnaces are working under pressure, and are readily disposing of the bulk of their output. The dearth of stocks at steel works makes early buying a necessity to cover new commitments. Makers of basic steel are busily engaged supplying the expanding needs of engineers and machinery makers. Some of the best-placed furnaces operated throughout the week-end in order to meet the demands of local rolling mills. A better tone is also displayed in crucible steel. Orders are more numerous and for larger tonnages. Lincoln and other agricultural engineering centres are taking larger deliveries of castings, plates and other machinery parts. The bulk of new orders, however, are from the textile and electrical sections. Conversion schemes have provided a considerable weight of contracts, and there is every prospect of new business on a big scale. Water turbines are on order for delivery to the Punjab in connection with irrigation schemes. Containers made of stainless steel have been ordered by British chemical works. Business in tramway rails and points and crossings is distinctly on the up grade. Sheffield Corporation has placed new contracts locally for tramway tyres, steel rails and steel switches. Implement makers are producing shovels and forks for winter stocking purposes. An expanding business is being done in circular saws. A Japanese customer has just placed an order for 450 of these.

South Yorkshire Coal Trade.—Local collieries are busy making up for time lost at Doncaster races. Deliveries of steam hards for shipment have got somewhat into arrear, and as the demand is on the up grade collieries have only a very small surplus to work upon. Steel makers, who contend that any rise in fuel prices will put them out of the market, are steadily augmenting reserves. Home railways are in the market for further contract supplies. Cobbles and nuts are featureless; a moderate business is passing in coking qualities. House coal merchants have been unable to maintain recently advanced rates for inferior grades. Quotations:—Best branch hand-picked, 36*s.* to 37*s.*; Barnsley best Silkstone, 33*s.* to 34*s.*; Derbyshire best brights, 23*s.* to 24*s.*; Derbyshire best house, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best large nuts, 19*s.* to 21*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.* 6*d.*; Yorkshire hards, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire hards, 19*s.* 6*d.* to 21*s.*; rough slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; nutty slacks, 7*s.* 6*d.* to 8*s.* 6*d.*; smalls, 3*s.* to 5*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

Cleveland Iron Trade.—Demand for Cleveland pig-iron for the United States continues, and Scotland is open to buy fairly freely, but there is now acute shortage of nearly all qualities, and consequently business is on a very limited scale. Most makers, in fact, have disposed of their output to the end of next month. The small parcels of No. 1, and of siliceous iron that come on the market are promptly purchased at 97*s.* 6*d.* There are buyers of No. 3 G.M.B. at 92*s.* 6*d.*, but it is very difficult to obtain any of the ruling quality at that figure, most makers naming 95*s.*, which figure however might be shaded for delivery over the last two months of the year. No. 4 foundry is 90*s.* and is not so scarce as the foregoing named qualities. Forge 4 is in fairly ample supply, and is selling at 85*s.* All quotations are f.o.t. makers' works, and f.o.b. Tees.

Hematite.—East Coast hematite is plentiful, producers having considerable stocks, but some makers are inclined to take a rather firmer stand after the little buying just reported, which includes further transactions with South Wales. Customers, however, report they can still place home and export orders for Nos. 1, 2 and 3 at 89*s.*, though there are manufacturers who ask 90*s.* and a little over.

Blast Furnaces Blowing.—The number of furnaces blowing is still far from what could be desired, but the hope is entertained that more idle plant will be in operation before long. Out of 114 furnaces erected on the North-East Coast, as yet only 30 are in blast. Of these 7 are turning out Cleveland pig-iron, 11 are making hematite, and 12 are producing other kinds of iron.

Furnace Coke.—Prices of Durham blast-furnace coke are irregular. Local consumers are very disinclined to pay more than 26*s.* for average qualities delivered, but sellers name 26*s.* 6*d.* to 27*s.*

Foreign Ore.—There is next to no business passing in foreign ore, consumers having good supplies and holding off the market. Best rubio is nominally 24*s.* 6*d.* c.i.f. Tees, but doubtless some sellers would favourably entertain offers at less, though on the other hand some firms declare they would not accept even the foregoing figure. Good Mediterranean ores are in the neighbourhood of 23*s.* c.i.f. Tees.

Manufactured Iron and Steel.—Some little improvement is noticeable in finished iron and steel. Inquiries are expanding, and a few orders for steel rails and for constructional work are reported to have been placed, but the volume of trade passing is still far from what could be wished. Home quotations depend largely on destinations, cost of conveyance on long journeys having to be taken into consideration. Competition for foreign business continues keen, and export contracts can be arranged at substantially below the following figures, which are named for local delivery:—Common iron bars, 10*l.* 10*s.*; iron angles, 11*l.*; iron rivets, 12*l.* 17*s.* 6*d.*; black sheets, 12*l.*; galvanised corrugated sheets, 16*l.* 10*s.*; steel bars, 9*l.*; steel billets (medium), 7*l.* 10*s.*; steel billets (hard), 8*l.* 5*s.*; steel boiler plates, 12*l.* 10*s.*; steel ship, bridge and tank plates, 9*l.*; steel angles, 8*l.* 10*s.*; steel joists, 9*l.*; steel tees, 10*l.*; heavy steel rails, 9*l.* 10*s.*; and fish plates, 14*l.* 10*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There has been almost no change in the position of the Scottish steel trade during the past week, and fresh business is as difficult to secure as it has been for the past month or two. Competition is very keen for whatever lines are on offer, and in order to obtain work to keep mills running, prices are being shaded. The actual figures being accepted are not generally divulged, but orders are frequently taken at rates which show no margin. For ship plates, the demand continues to be infinitesimal, but there is still a little doing in structural sections. The makers of black sheets are rather quiet, and most of the business still passing is for the thin gauges on export account. The current quotations are as follow, but as already noted, these are subject to cutting:—Boiler plates, 12*l.* 10*s.* per ton; ship plates, 9*l.* per ton; sections, 8*l.* 15*s.* per ton; and sheets, ¼ in., 10*l.* 5*s.* per ton, all delivered Glasgow stations. For export, plates are quoted round 8*l.* 10*s.*, and sections round 8*l.* per ton.

Malleable Iron Trade.—The bar iron makers in the West of Scotland are still complaining of an absence of demand, and have much difficulty in picking up enough work to keep part of their plant in operation part of each week. The outlook is far from bright, and there seems little prospect of any improvement in the meantime. The price of "crown" bars is unchanged at 10*l.* 10*s.* per ton, delivered Glasgow, and about 5*s.* per ton less for export lots.

Scottish Pig-Iron Trade.—The Scottish pig-iron makers have been benefitting considerably during recent weeks through the continued demand for foundry iron for America, and there are prospects of a fair amount still being required for the same destination. Stocks have almost disappeared, and the relighting of several more furnaces is assured shortly. The home demand is certainly not the bright side of the trade at present, but a revival may set in before long, although many are not very sanguine on that point. In hematite iron there is very little doing at the moment, and there seems little hope of buying getting any better for some time to come. The foreign demand has stimulated quotations, and these may be taken to-day as follows:—Foundry iron, No. 1, 5*l.* 5*s.* per ton, and No. 3, 5*l.* per ton, ex makers' works; and hematite, 5*l.* 7*s.* 6*d.* per ton, delivered at the steel works.

Shipbuilding.—With the shipbuilding industry so quiet, it is welcome news to learn that the Fairfield Shipbuilding & Engineering Company, Limited, have received orders from the Union Steamship Company of New Zealand, to proceed with the construction of a liner placed by them some time ago. The high costs of production necessitated the temporary cancellation of this contract. An order has been booked for one of the yards in the lower reaches of the Clyde for a new vessel of 8,000 tons deadweight carrying capacity. The shipowners who have placed the contract are Messrs. W. S. Miller and Co., Glasgow. Tenders are now under consideration by the Orient Steam Navigation Company for a new vessel which they are about to place. The successful firm to secure the contract is not yet officially decided, but several of the Clyde shipbuilding firms have offered.

THE INSTITUTION OF MINING ENGINEERS.—We are informed that the annual general meeting of this Institution will be held in London on the morning of Thursday, November 16, and Friday, November 17. The programme of papers, &c., will be issued later.

MANCHESTER ASSOCIATION OF ENGINEERS.—By the courtesy of the directors of the Metropolitan-Vickers Electrical Company, Limited, arrangements have been made for the members of the association to visit the company's works at Trafford Park on Wednesday afternoon next, the 27th inst., the members to assemble at the works at 2 p.m. On Saturday afternoon the 23rd inst., the student members will visit the works of the National Gas Engine Company, Limited, at Ashton-under-Lyne.

AMERICAN ARMY AIRSHIP FLIGHT.—The "A.4," one of the oldest dirigibles in the United States army service recently made a successful 16-hour flight from Langley Field, Virginia, to Akron, Ohio, the total distance covered being about 700 miles. Prospective landing fields *en route* were photographed and a stop was made at Wingfoot Lake Air Station, where the ship was built by the Goodyear Tyre and Rubber Company, for the purpose of fitting mooring gear. The ship will be moored to a mast at Scott Field, Illinois, near St. Louis, until new hangars are completed there. These hangars will be 800 ft. in length—the largest in the United States. The A.4 is only half the size of the new dirigibles now being built.

NOTICE OF MEETING.

THE INSTITUTE OF COST AND WORKS ACCOUNTANTS.—Wednesday, September 27, at 7 p.m., in the Hall of the Chartered Institute of Patent Agents, Staple Inn-buildings, Holborn, Mr. R. Stelling, F.C.W.A., will give an address on "Collection of Data for Ascertaining Overhead Expenses." The chair will be taken by J. M. Fells, Esq., O.B.E., F.C.W.A.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The outlook in the Welsh coal trade is very unsettled. The question of the unemployment of non-unionists was again considered by the executive council of the South Wales Miners' Federation yesterday, when it was reported that the districts were in favour of tendering notices. It was decided to call a delegate conference for Saturday week to consider the whole matter. At yesterday's meeting of the Conciliation Board, the application of the workmen for a subsistence allowance for the lower-paid men of an extra 1*s.* per day for men over 21 years of age, 9*d.* for those 18 to 21, and 6*d.* for boys, with a maximum of 7*s.* 9*d.* per week was considered. The Board failed to arrive at a settlement, and the matter will be referred to Lord Buxton, the independent chairman of the Board, for his decision. Meanwhile the demand for coal has slackened off appreciably, and prices are much lower. Best Admiralty large is freely available at 26*s.* 6*d.*, compared with 30*s.* a few weeks ago, while smalls range from 9*s.* to 16*s.* 6*d.* against 17*s.* to 22*s.* 6*d.* Even at these reduced prices, sellers find it difficult to secure sufficient orders to keep the pits working regularly, and it is feared that unless there is an early improvement, stoppages will become frequent. The only exception to the weakness is that in respect to large dry coals, which are steady at 28*s.*, because of the fact that collieries are comfortably booked up with orders for Canada. In August, 2,299,989 tons of coal were shipped from South Wales to foreign countries, compared with 1,907,522 tons in July and 1,940,795 tons in June. Of the August exports, 572,148 tons, or 25 per cent. of the total, went to North America, 508,866 tons going to the United States, and 63,282 tons to Canada. Shipments to all other countries with the exception of Portugal, showed a reduction in August. Exports to France totalled 582,736 tons, to Italy 319,779 tons, to South America 186,129 tons, to Spain 156,194 tons, to Portugal 78,074 tons, to Greece 10,919 tons, to British coaling depots 107,136 tons, and to "other countries" 286,874 tons. Exports from Cardiff amounted to 1,413,496 tons, from Newport to 424,385 tons, from Swansea to 227,822 tons, from Port Talbot to 182,152 tons, and from Llanelly to 52,134 tons.

Iron and Steel Trades.—The demand for Welsh tinplates is inactive, and with current prices below the cost of production, there is talk of works closing down. On the other hand, there is an improved demand for galvanised sheets, and prices are firm at 16*l.* 5*s.* per ton for 24-gauge corrugates in bundles. Standard boxes of tinplates are barely steady at 19*s.* for forward delivery and 19*s.* 3*d.* for prompt plates. Shipments of iron and steel goods last week totalled 3,233 tons, against 16,566 tons a week earlier. Black plate exports totalled 801 tons compared with 1,332 tons; tinplates, 1,745 tons against 9,714 tons; galvanised sheets, 138 tons, against 1,914 tons; and iron and steel, 548 tons, against 3,606 tons.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—A metropolitan district meeting is to be held at Poplar and the Port of London Authority's docks on Friday, the 29th inst. The Poplar housing schemes, refuse destruction, &c., and the Limmer and Trinidad Lake Asphalt Company's works, Blackwall, will be visited. Particulars can be obtained from Mr. E. F. Spurrell, Holborn Council Offices, 197, High Holborn, W.C.

REFRACTORY MATERIALS SECTION OF THE CERAMIC SOCIETY.—The Refractory Materials Section of the Ceramic Society will hold their 11th annual meeting at the Council Chamber, Chamber of Commerce, 95, New-street, Birmingham, on Tuesday and Wednesday, October 3 and 4, 1922, when Lieut.-Colonel C. W. Thomas will preside. The following papers will be taken in the order given as far as time permits:—Tuesday, at 10.30 a.m., discussion on "Bricks for Coke Ovens"; at 12 noon, "Technical Education in the Refractories Industry," by Mr. G. W. Hefford (Board of Education); at 2.30 p.m., "Some New Forms of Kilns," by Sir Arthur Duckham; at 3.15 p.m., "The Grading of Silica Bricks," by Mr. P. B. Robinson, M.Met., and Mr. W. J. Rees, B.Sc.; at 4 p.m., "Note on the Abrasion of Fireclay Materials," by Mr. W. C. Hancock, B.A. (At 7 o'clock p.m., dinner at the Grand Hotel, Colmoré-row.) On Wednesday, at 10 a.m., "The Behaviour of Clays on Heating," by Mr. H. S. Houldsworth, B.Sc., and Professor J. W. Cobb; at 10.30 a.m., "Some Changes taking place in the Low Temperature Burning of Stourbridge Fireclays," by Mr. C. E. Moore; 11 a.m., "An Examination of Refractories by the Oxygen Hydrogen Blowpipe," by Mr. A. L. Curtis; 11.30 a.m., "Graphic Methods of Determining the Stresses in Furnace Walls owing to Temperature Differences," by Professor C. H. Lees, D.Sc.; at 12 noon, "X-Radiogram of Kaolinite, and the Thermal Decomposition of Clay," by Professor W. H. Bragg, D.Sc., and J. W. Mellor, D.Sc. The afternoon meeting is to be given over to the general business of the section and the election of officers.

BOILER DEPARTMENT AT THE ELSWICK WORKS.

MESSRS. SIR W. G. ARMSTRONG WHITWORTH AND CO., LTD., NEWCASTLE-ON-TYNE.

(*For Description, see Page* 373.)

FIG. 1.—MIDDLE BAY, LOOKING WEST, AUGUST 18, 1922.

FIG. 2.—NORTH BAY, LOOKING WEST, AUGUST 18, 1922.

TWO-CYLINDER, SUPERHEATER, 4-6-2 LOCOMOTIV

CONSTRUCTED BY THE SOCIÉTÉ ALSACIENNE DE CONST

(For Description, see Pa

Fig. 1.

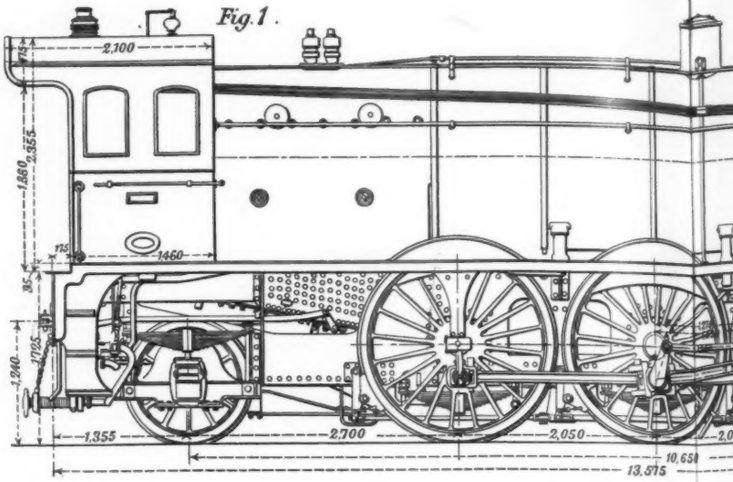


Fig. 2.

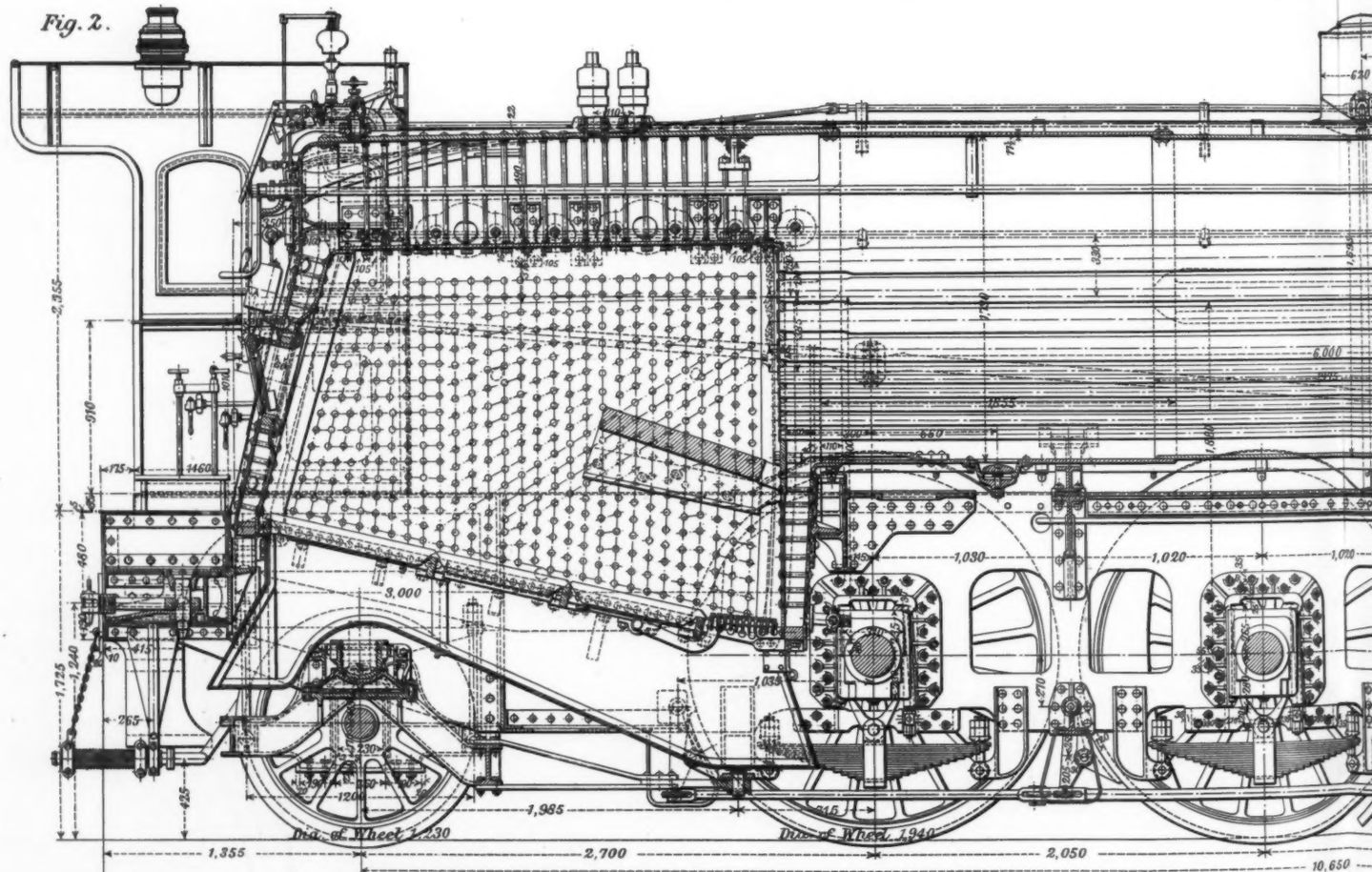
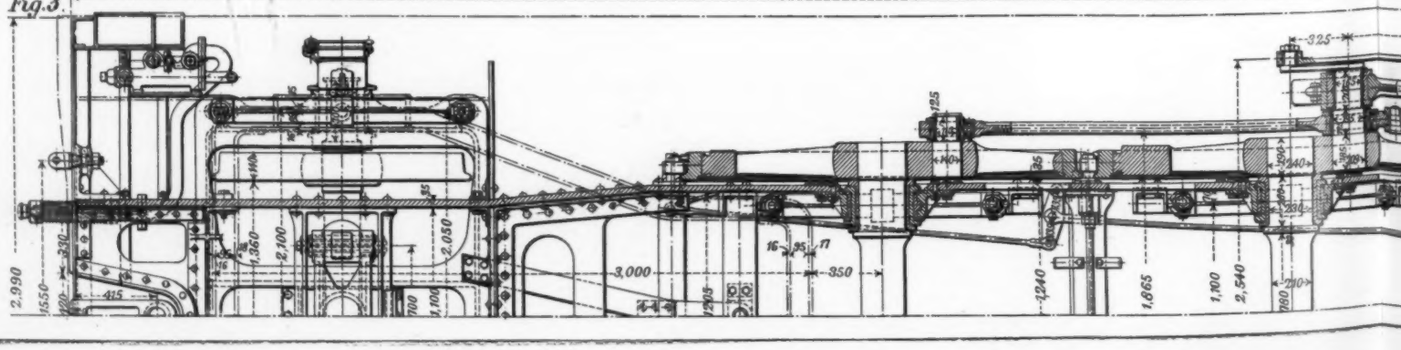


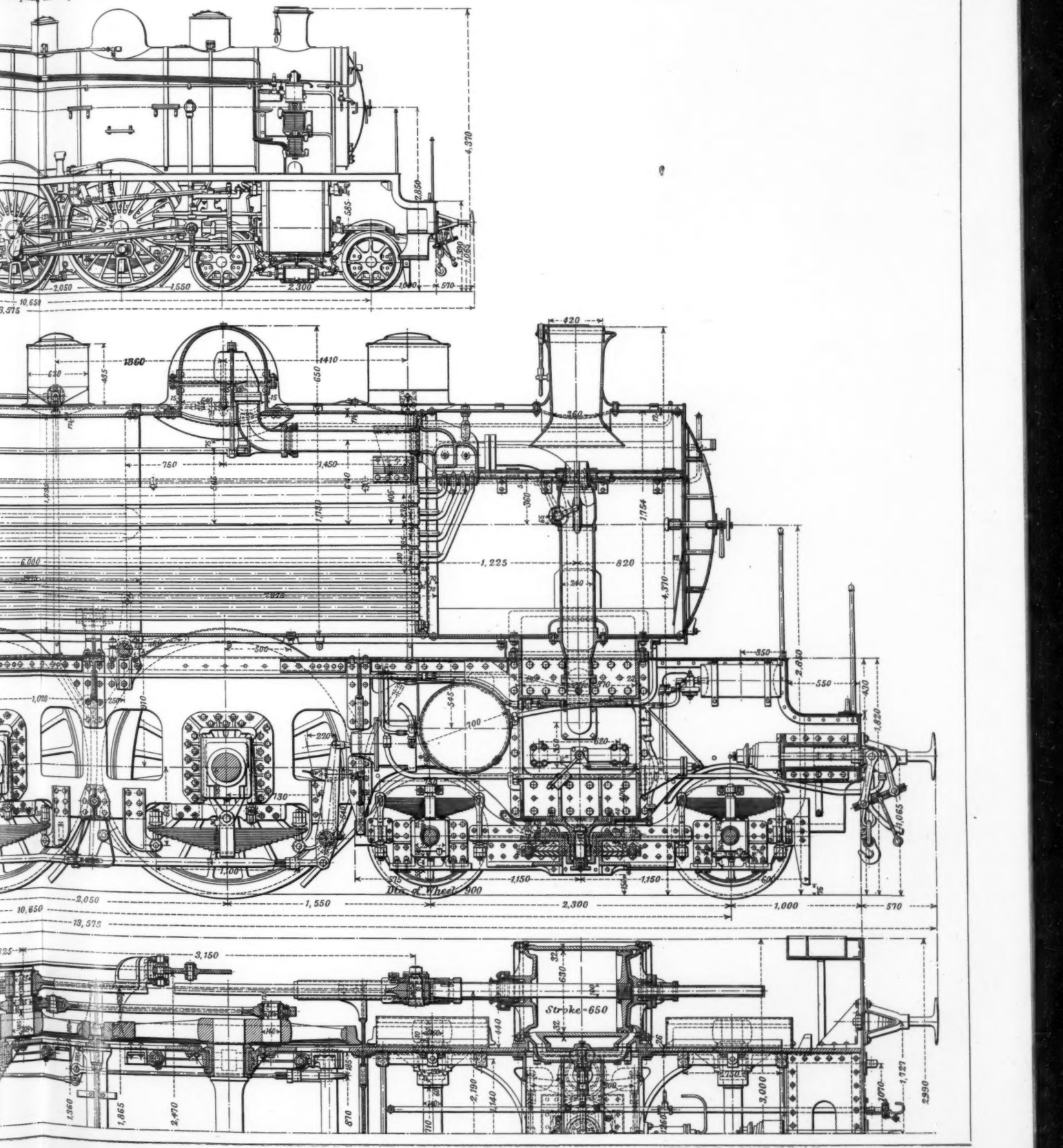
Fig. 3.



OMOTIVE FOR THE CHEMINS DE FER DU MIDI.

NE DE CONSTRUCTIONS MÉCANIQUES, BELFORT, FRANCE.

Description, see Page 360.)



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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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ENGINEERING.

FRIDAY, SEPTEMBER 22, 1922.

THE POSITION OF THE ELECTRICAL INDUSTRY.

It is well at times to stand back and take a comprehensive view of any subject in the details of which one is usually immersed. Only by so doing can one get the true perspective which is so essential to sound judgment. In the case of an industry the salient features are continually changing, and it is particularly important that those engaged in it should note from time to time the broad developments which are taking place with a view to the guidance of their own conduct. Industries, like other human organisations, are in their very nature subject to change. They are sensitive not merely to the comparatively brief and shallow waves of fashion and sentiment, but they also respond to the more deep-seated and irreversible changes which take place in society generally. The former have only a temporary significance, for like the swing of a pendulum, they involve no lasting departure from the mean conditions. They may be better likened to the higher harmonics rippling the fundamental wave of human progress, with no perceptible influence on the slow secular changes whose period is so long that for all practical purposes it is conterminous with civilisation itself. These irreversible changes in the industrial system are brought about by the spread of education, the evolution of social consciousness, the ramifications of political and financial interests, the facilities of transport and other causes connected with the progress of civilisation. They may be guided, but they can neither be suppressed nor ignored.

Never since the modern industrial system has existed has it been subjected to such strains as were thrown upon it by the war. The necessities of the time compelled the abandonment of sound principles in favour of expedients contrary to economic laws, and indeed the very existence of these laws was often denied by those who could not see the slope down which our industries were travelling. When the war came to an end there was a short period of feverish industrial activity due to the urgent demand for goods, and it almost looked as if the warnings of those who had foreseen bad times were to be falsified. But the inexorable laws of economics reasserted themselves with surprising suddenness. For several years the country had been living on its savings and its credit, and the money which circulated so freely during those years was as costly as the warmth which a man may enjoy while his house is burning. The termination of the war put an end to this fictitious prosperity, and the nation found itself 8,000,000,000*l.* poorer than it had been before the war, and, moreover, deeply in debt. Its freedom had been saved, but at so great a loss of the national wealth that it was obvious that the average standard of living could only be maintained if production was increased enough to provide a margin sufficient to pay our debts and replace our investments. Hard work was therefore preached as the road towards industrial recovery, but the doctrine could not be acted upon when the order books were empty. The links of commerce had been broken, markets had been lost, and many of our former customers were too impoverished to do much business. Many and great readjustments of the industrial machine were necessary before it could be got to work smoothly again and produce its full output under the new conditions.

All of our leading industries have suffered in greater or less degree from the disruption of commerce, and the problems they have to face are in general of a similar nature. But each has its own peculiar difficulties in addition to its share in the common burden, and similarly each may derive some consolation from circumstances which affect it alone. It is a truism in engineering that if a problem can be stated with sufficient definiteness, the solution is generally rendered obvious, and a clear exposition of the conditions from which any industry is suffering is bound to be helpful in indicating the way to remove them. This was undoubtedly the idea underlying Mr. W. E. Highfield's presidential address last week to the National Society of Supervising Electricians. His theme was "The Position of the Electrical Industry To-day," and speaking as one prominently identified with this industry to an audience whose livelihood largely depended upon its prosperity, the subject was well chosen. It was indeed particularly appropriate, for the society is mainly composed of foremen and others who may be called the non-commissioned officers of electrical engineering. For such a body of men to have authoritatively presented to them the larger facts of their industry, so that they can trace existing troubles to their true economic causes, is to ensure their hearty co-operation with their leaders in efforts to set the industry again on the road to prosperity.

Many of the changes which Mr. Highfield noted as having recently occurred in the electrical industry were irreversible ones. Whether these were changes for better or worse he did not discuss, and discussion indeed would be useless. The only thing to do is to recognise things as they are, and make the best of the new conditions. Amongst these is the tendency towards huge industrial amalgamations. The private owner of works and even the small companies are falling out of existence and being replaced by great corporations with very widespread interests. The inevitable result is that industry is becoming more largely controlled by financiers, who are personally ignorant of the technical details of the business, but who direct its course from financial considerations. The large companies certainly have the power to undertake enterprises on a scale quite beyond the means of smaller firms, but how far this power has been gained at the expense of the technical strength of the organisations time only will show. The intimate knowledge of his business and his pride in the works which he or his forbears founded were great assets to the manufacturer of the past generation, and the great problem before the big organisations of to-day is to combine similar traditions with the centralised management of huge industrial combinations.

Another recent feature of industry which is certainly correlated with the "long distance" control to which we have alluded is the change which has taken place in the works organisation. Before the war the organisation of the shops was largely

built around the foreman system. Each foreman was responsible to the works manager for the efficiency of his particular department, the discipline of the shops, and the quality of the workmanship. Now, Mr. Highfield remarked, the system had been very largely superseded by the principle of "management by committee." The committee system was slow in operation and led to a large amount of secretarial work. The departmental foremen still existed but their functions were largely modified. Their power of discipline had vanished because the engaging and discharge of men had been removed from their jurisdiction. Their personal supervision and instruction as to methods of manufacture had been replaced by systems of cards and checks controlled by some central office. The foremen no longer remained the accredited channel of communication between the men and the works manager, this function having been taken by the shop stewards. Whether the change was for better or worse Mr. Highfield did not express any opinion. He confined himself to emphasising the fact that it had certainly occurred, and that it was one of the irreversible changes which could not be ignored when considering our manufacturing efficiency.

Whether the abolition of the powers and responsibilities of the foremen in favour of "committee" control and clerical system had been responsible for the deterioration in the quality of workmanship which marked the return of the factories to normal work, it is not easy to say. Before the war the pride of craftsmanship and the tradition of good work were strong in the workshops. Then for several years the works were filled with unskilled men supervised by a mere skeleton of skilled workmen. The only standard of workmanship was the gauge of the Government Inspector, and so long as this was satisfied nothing mattered but output. Such an experience could hardly help being demoralising to craftsmanship, and when the reign of the inspectors was over, the traditions of good workmanship for its own sake had largely vanished. The foremen had no longer the power to enforce workmanship up to the old standards, even had the skill to produce it been available. In speaking of the deterioration of quality since the war Mr. Highfield was especially emphatic. The evil affected both design and workmanship, and the commonly heard claim that some article was "pre-war quality" was standing evidence of the deterioration which had taken place. One of the very greatest assets of the British manufacturer had always been his reputation for high-grade goods, first-class in design, material and workmanship. A reputation is far more easily lost than regained, and if our designers and workmen were going to be satisfied with the production of things which they thought were "near enough," and our inspectors thought "they might go through," and the testing department "reckoned they would be all right on site," British industry could never regain its old position.

In dealing with the future of the electrical industry in this country, Mr. Highfield spoke hopefully though cautiously. The fact that the country was poor, and the necessary consequences of this fact, were slowly becoming realised by the public at large. The trade returns showed that the nation was slowly settling down to work again, and with a cessation of the industrial unrest which had been so disastrous of recent years confidence was being restored. The conditions of manufacture were so changed that it was as yet impossible to forecast at what level manufacturing costs would remain, but with greater stability the true effect of the changes would become evident. The production of electrical apparatus for home use was bound to be stimulated by the developments of electricity supply which were coming about as the result of the Electricity Act. The present aggregate power of the generating plant installed was given by Mr. Highfield as about 2½ million kilowatts, a total which will be considerably increased within the next few years. As a consequence of the installation of generating plant there would be orders for machinery and apparatus of all kinds to use the current, so that the electrical manufacturing industry may look forward with confidence to a certain amount of activity. It may be pointed out, in this connection, that if we can stimulate the demand for electricity to anything like the extent that has been reached abroad, the activity will be very great indeed. Even our great manufacturing districts do not approach the consumption per head which is realised in the little prairie towns of Canada, and we recently called attention to the case of Shanghai with its load factor of 51·5 per cent., and an annual output of 185 million kilowatts per annum, which, moreover, is increasing yearly at the rate of over 20 per cent. It is surely extraordinary that Glasgow should fall far behind Shanghai in the consumption of electricity and that Liverpool should have less than half the consumption. An extensive development of electricity at home is the best foundation for our success in selling electrical apparatus abroad, especially if our own stations are equipped, as they should be, with machinery which for design and workmanship is the best in the world.

SCIENTIFIC AND INDUSTRIAL RESEARCH.

PROBABLY few of us have been free from the fear that it may be a more difficult task for this country to recover from the exhaustion of the recent war than it was to make good the heavy losses due to the Napoleonic struggle. From that it is generally admitted, France, though in the end the unsuccessful combatant, repaired her war losses more rapidly and more easily than we did, a circumstance which has been attributed to the less advanced state of her manufacturing industries, the body politic like the living organism having greater powers of self-repair the less highly it be developed. A hundred years since we had, however, certain advantages over other countries which we no longer possess. In particular, we had relatively cheap power, but to-day power costs less in many other countries than it does here. We were, moreover, at that time the principal coal-winning nation of the world. Our natural resources, either in extent or development, are now no longer unrivalled by those of other civilised nations, and the task of liquidating our enormous liabilities will have to be faced under greatly changed conditions. In any successful solution of the perplexing problems now presented to us, the moral factor, no doubt, will prove not less important than the material, but it is with the latter alone that we propose to deal here. The very circumstance that the industrial development of other countries is now comparable to that of our own, renders it all essential that we should make the best of such advantages that remain to us, and it was to this end that the Department of Scientific and Industrial Research was originally founded. Pioneers working on virgin soil may reap a profitable harvest in spite of crude methods of culture, but conditions are now changed, and to advance our industries, native ingenuity, and common sense must be supplemented by erudition and reasoned research to a much larger extent than heretofore.

The fact that an object may be inherently desirable is not of itself sufficient to justify its immediate pursuit, and from their last report* it appears that the Department of Scientific and Industrial Research has been called upon to overhaul its expenditure just as have other departments of State. Within a period of 18 months it had to consider no less than three appeals to this end. In obedience to the first two its outlay was reduced by a total of 34 per cent., but to the third appeal a *non possimus* reply was made, and in this we are glad to note it was sustained by the Geddes Committee. It was held that in at any rate four of its activities the department was so directly connected with the future welfare of the nation that the responsibility for any slackening in these must be shouldered by the Government. Thus the National Physical Laboratory must be maintained, although it has been found possible by postponing certain work to reduce the annual expenditure by 25,000*l.* The operations of the Fuel Research Board are clearly of the greatest importance, and in view of the necessity of conserving our national mineral reserves, it was felt that the Geological Museum and Survey must also be maintained.

The work of the Food Investigation Board has already yielded results of great economic value, and as we import so large a proportion of our foodstuffs from overseas it is obviously highly desirable that its operations should continue. Expenditure on other departments has, however, been restricted save in cases where the work already done was either near completion or where its suspension or abandonment would involve the scrapping of a research just as really useful results were beginning to be obtained. Fortunately the million fund with which the department was originally endowed has, in these hard times, proved of the utmost value and made it possible to avoid this waste. The unexpended balance of this fund now amounts to 817,000*l.* but much is already ear-marked for researches now in progress, and ultimately the different research associations which have been formed will be required to carry on with their own resources. The total expenditure of the department during the year was 525,580*l.*, of which over 100,000*l.* was obtained from fees paid for experiments at the Froude National Tank or for investigations of another kind.

The question is certain to arise as to the value of the results obtained, but like Mr. Silas Wegg's estimate of his business losses, it is difficult to work it into money. The use of the Froude tank, however, is said to result in a saving of from 2 per cent. to 10 per cent. on a shipowner's coal bill, and in addition to such positive gains to trade there have, it appears, been cases in which on the advice of the department plans which would have cost millions to execute have been abandoned. An incidental gain is the growing confidence of other departments of Government in the advantage of scientific knowledge.

Directly valuable results have been secured by many of the research associations which have been financed in part by the department and in part by the trades concerned. In this country many trades are carried on by numerous small firms, whilst in America or Germany practically the whole of such trades has been concentrated into the hands of a few large undertakings. It has thus been easier in those countries than here to establish adequate private laboratories for research. The benefit thence derived was particularly marked in the case of refractories; and it will be remembered that when establishing his experimental steel furnaces at Sheffield University, Professor Arnold had at the outset to import his fire brick because this imported article, in spite of an analysis which an aggrieved British maker said he would be ashamed of, outlasted the native product by many heats. Ultimately, however, Professor Arnold was able to obtain equally satisfactory material here, but the prior condition would never have arisen had our own makers been in a position to conduct the same fundamental researches as their foreign competitors. By the co-operative research associations now provided, this disability has been removed.

None of these research associations is yet five years old, though two are approaching this limit. One of the earliest founded was the British Portland Cement Research Association, and it is gratifying to note that several works express themselves as highly satisfied with the results obtained. Wear and tear has been reduced and coal consumption diminished in spite of a much increased output. One firm rates as of still higher value the advantage gained by "the spirit of accuracy and the spread of knowledge of how science can be applied," which has resulted in an annual saving of 25,000*l.* on fuel costs. Another firm states that in one department the labour required has been reduced by one-third as the result of the help rendered by the research association.

The British Scientific Instrument Research Association, again, has, as the result of a "fundamental" investigation into the action of polishers and abrasives, learnt how to prepare a variety of rouge which is far superior to all pre-existing polishing agents, and also an abrasive which greatly facilitates the grinding of lenses. By the use of this hand work has been eliminated, and the time required for grinding is but one-third of what was formerly needed. The surface produced by the grinding is, moreover, so good that the time required for the subsequent polishing is only two-thirds of that previously necessary. It is interesting to note that

* Report of the Committee of the Privy Council for Industrial and Scientific Research for the year 1921–22. Cmd. 1735 H.M. Stationery Office. Price 3*s.*

a period of two years was required to introduce this rouge and abrasive into regular industrial use, it being necessary to educate the workmen as well as to convince the employers.

The advantage of investigations of a fundamental character have also been strikingly shown in connection with food conservation. At the outset some of the firms concerned were disposed to question the need, from their standpoint, of studying the physiology of living and dead stuffs, but the results have proved of immediate and surprising value. For example, three cargoes of Australian apples suffered losses from "brown heart," valued in one instance alone at over 3,000*l*. Previous reports on this mysterious "disease" attributed it entirely to injury by insects whilst the fruit was still in the orchard, but it has now been shown to be due entirely to the "suffocation" of the apples during the voyage by the carbonic acid gas they had themselves produced.

One very curious statement is made in respect to other work of this committee. In pre-Pasteur days putrefaction or spoiling of food was attributed to the action of the oxygen of the air, but the general view for long past has been that bacterial agency was invariably responsible. It appears, however, from the present report that the Canned Foods Committee state that they have found minute holes in tins to occasion "spoilage," not because they permit the entry of bacteria but because of access of traces of oxygen to the contents. This seems a remarkable reversion to discarded ideas, and the publication of the committee's report will be awaited with interest. The Food Investigation Board is naturally concerned with refrigeration problems, and Professor C. F. Jenkin has accordingly been studying, on their behalf, the total heat of liquid carbonic acid gas. This investigation is now complete, and will be of much more than industrial interest, since CO_2 is the only common material of which the critical point is readily accessible, and the critical phenomena of all vapours are still much in need of further elucidation.

The operations of the Fuel Research Board have also led to a result of general scientific interest, since Sir George Beilby has discovered in coke a vitreous form of carbon. The main work of this board has been devoted to the improvement of methods of gas making, and it has been shown that by steaming in vertical retorts the heat units in the gas can be increased 25 per cent. to 30 per cent., and there is at the same time an increase in the yield and on the value of the by-products. Low temperature carbonisation has also been carefully studied, and the Fuel Research Board are now inclined to believe that the process can be made a commercial success. The board has also devoted much attention to the subject of coking, and has proved that the range of recognised coking coals can be materially extended.

One vexed subject they are attempting to standardise is the taking of coal samples for analysis or for the determination of calorific value. In this matter existing practices vary very widely indeed.

Work of engineering interest now in progress at the National Physical Laboratory includes a repetition of Tower's experiments on the lubrication of a cylindrical bearing. It seems unlikely that this will add much of value to Tower's observations, although the difference in the radii of the brass and the journal is to be measured. A journal bearing is, however, very ill adapted to a fundamental research on lubrication. As Reynolds himself pointed out, no less than three "parameters" come into the mathematical study of such a bearing, even if it could be regarded as of infinite length. These are the difference of the radii, the eccentricity of journal and brass, and the least thickness of the oil film. If the fact that the brass is of limited length be also taken into account, we get a fourth "parameter," and to this must be added a fifth due to the distortion of the brass under its load. Any even approximately adequate comparison between theory and observation will thus involve an appalling amount of arithmetic, the need for which would have been avoided had the laboratory chosen to make its experiments on a Michell block or pad. A statement is made in the report that there has been a breakdown in the lubrication of modern high-speed bearings of large size. Inquiry has failed so far to yield us particulars of these, and indeed one engineer appealed to expressed himself as incredulous as to their existence, as Betsy Prig did of that of Mrs. Harris. In any case it is certain that if such cases have occurred they are not due to the cause stated in the report, where Osborne Reynolds' suggestion that lubrication fails from the inset of turbulence is repeated. This hypothesis is not merely mechanically inconceivable but is also mathematically impossible. A pioneer cannot be expected to realise all the implications of the formulas he has himself established, and the view in question constitutes one of Reynolds' mistakes. It is unfortunate that the error should be propagated further through the medium of an official report.

THE PORT OF LONDON AUTHORITY.

The report for 1921 of the Port of London Authority, which has just been issued shows an increase for 1921 over the year 1920, in the tonnage arriving and departing, of over a million and a quarter. The tonnage paying dues for the last year amounted to 25,730,336, compared with 24,320,249 tons in the previous year—an increase of 5 per cent. The figures show an increase of 12·4 per cent. in the foreign trade, and a decrease of 12·3 per cent. in the coastwise trade of the port. The shipping making use of the wet docks of the authority amounted to about 63·7 per cent. of the whole, this figure showing a tendency to increase slightly. The ships using the Authority's dry docks represented a tonnage of 2,431,461, also a slight increase on the previous year. It is noticeable that while in 1921 the trade of the United Kingdom fell from nearly 3,500,000,000*l*. to less than 2,000,000,000*l*., the premier position held by Liverpool in 1920 reverted to London in 1921. The latter port last year showed trade in imports and exports (excluding coastwise trade) amounting to 606,856,886*l*., while Liverpool only accounted for 528,012,834*l*. In the previous year both had been well over the 1,000,000,000 mark. During the year the authority issued 2,000,000*l*. of inscribed stock, chiefly to pay off temporary loans. The capital expenditure during the year amounted to 1,472,818*l*. The total revenue was 7,929,874*l*., and the total expenditure 5,801,217*l*., leaving a balance of 2,128,657*l*. After deductions for income tax, &c., a balance is left of 552,728*l*., which, with a balance of 896,044*l*. carried over from the previous year gives a balance to carry forward of 1,448,772*l*. The year 1921 was notable in the history of the port on account of the opening of the King George V. Dock, described in these columns at the time (see vol. cxii, page 2). A good many other improvements were also carried through, including the river jetty at Tilbury opened on June 9, 1921. During the year 2,161,553 cub. yards were dredged from the river, and 1,230,343 cub. yards of mud were removed from the docks. Twenty-six sunken vessels were cleared from the river by the wreck-raising plant during the year, representing about 2,200 tons.

THE INSTITUTE OF METALS.

THE autumn meeting of the Institute of Metals, which is being held this week at Swansea, opened last Tuesday evening, when the first annual lecture on subjects of practical interest to those engaged in the non-ferrous metals industry was delivered by Dr. R. S. Hutton, member of the Council. It will be remembered in this connection that at the last September meeting, held in Birmingham (see ENGINEERING, vol. cxii, page 448), the chairman, Vice-Admiral Sir George Goodwin, past president, announced that the council had entirely agreed with a suggestion made by Mr. G. W. Mullins, the Birmingham hon. local secretary, to the effect that at each provincial autumn meeting a lecture be given which would appeal to a wide circle of scientists and also workers, the latter term to be understood in its widest sense.

Dr. Hutton who was introduced to the meeting by the president, Mr. S. Sumner, chose as his subject "The Science of Human Effort (Motion Study and Vocational Training)." He stated that several conditions were essential for the satisfactory exercise of human effort: health, strength, comfort and environment, and training. The thorough consideration of these matters was now a duty of all employers and demanded the willing co-operation of the workers. Among his illustrations he stated that the percentage of total deaths due to phtisis amongst grinders and in the general population of Sheffield, was in the five years 1908–1912, grinders 51·2 and general population 7·7 per cent.; in the five years 1917–21 the figures were, grinders 37·8 per cent. and general population 7·6 per cent. The Home Office, he added, was completing a report on the grinding of metals and the effect of dust; this report would doubtless lead to revised regulations which, it was to be hoped, would go a long way to improving conditions in this trade.

Feeding, canteens, comfort and environment, protective garments, seating, lighting, ventilation, or merely the suitable arrangement of plant and machinery, Dr. Hutton further stated, were well known as being important factors in modern factory efficiency. The percentage reduction in summer in tin plate rolling varied from 3 per cent. in works where the state of artificial ventilation was good, to 13·4 per cent. where there was no artificial ventilation, the natural ventilation being a poor one.

Industrial psychology depended largely upon detailed observation, and it was quite useless to expect it to make headway without the full support and co-operation of those whose efforts were to be studied. It was fortunate that in England the subject had been taken up by a highly-qualified body, the Industrial Fatigue Research Board, which was now under the Medical Research Council. More recently, Dr. Hutton added, the Institute of Industrial Psychology had been founded to supplement and to apply the work of the Board, and had been enabled to carry out for individual establishments, studies of interest. Professor C. S. Myers, F.R.S., had recently resigned his professorship of Psychology at Cambridge University, to take up the directorship of the Institute of Industrial Psychology.

Industrial psychology, said Dr. Hutton, came under the following divisions: Vocational selection, fatigue studies, time and motion studies, training, and here Dr. Hutton reviewed the work under each carried out in different countries. In regard to training, Dr. Hutton stated that one could not help being struck with the fact that when it was a question of the pastimes of the community—music, golf or football—special muscular training and detailed movement studies were commonly recognised as essential, whereas even in the more skilled trades little, if any, such investigation and training had been adopted. Here, Dr. Hutton referred in detail to time and motion study applied to metal polishing from commencement to finish, pointing out the time that could be saved, after instruction of the special training of workers who had previous experience in the trade.

In concluding his lecture, Dr. Hutton stated that a great deal of our present-day misunderstanding in the industrial sphere was due to ignorance of the aspirations and mentality of the worker by employers, almost as much as to the lack of knowledge of basic economic principles of industry and commerce. There were in most branches of industry no such wide differences of view as some people imagined. Where this was recognised, the possibility of devising schemes for improving output and reducing hours of labour was open to us.

On the members assembling in Llewellyn Hall, Y.M.C.A., on Wednesday morning, the 20th inst., they received a most hearty welcome from the Mayor of Swansea, Alderman William Owen, J.P., who expressed the pleasure felt by the aldermen, council and burgesses of Swansea at receiving in their midst scientists who had done so much for the progress of their town. Swansea was an old town; its charter dated back to about 1200, and it had acquired great importance by the development of the metal industries. It could even be said that the metal trades had placed Swansea in the proud position of the greatest metallurgical centre in the world; this, the mayor added, might be challenged, but if challenged, it was nevertheless true. Smelting commenced a few miles away about 300 years ago, and had so developed since, largely owing to the work of the Vivian family, that from just over 6,000 inhabitants in 1801, the population

had risen to 145,000 in 1921. At the commencement, the ore smelted chiefly came from Cornwall, but after a short time the South American ore trade was opened, and the ore from Chile and other distant parts was brought by sailing ships, then by steamers, in ever-increasing quantities, this making for the progress of the town both industrially and commercially, from stage to stage. This was also coupled with progress in science, and here Alderman Owen mentioned the recent foundation of University College, the metallurgical department of which was under Professor C. A. Edwards' distinguished control. The work of the college was greatly appreciated in the town by the manufacturers, since it pointed to further developments. The Landore quarter of the town, the industrial quarter, was no doubt an unattractive one, but when the smoke in it was thick this was a good sign, since it was a sign of plenty of work. Here the mayor paid a tribute to the late Sir Richard Martin, who died suddenly in London recently, and had done a great deal towards the founding of the Swansea University College. In concluding, the Lord Mayor confirmed his welcome and expressed the hope that the members would find their stay in Swansea both an instructive and a pleasant one.

After a welcome on the part of the staff of University College, and a few words by the town clerk, the chairman, Mr. L. Sumner, expressed to the authorities of the town and of the college the thanks of the Institute for their cordial reception. He added that the Institute had long wanted to visit Swansea, since the metals it dealt with, copper, nickel, silver, gold, among others, were those to which the Institute gave their special attention.

SIXTH REPORT TO THE CORROSION RESEARCH COMMITTEE.

The first paper taken at the meeting on Wednesday morning was the "Sixth Report to the Corrosion Research Committee of the Institute," by Dr. Guy D. Bengough and Mr. J. M. Stuart. This report dealt with the nature of corrosive action and the function of colloids in corrosion; it contained an appendix on terms used in colloid chemistry.

The authors gave a general discussion of corrosion phenomena based on the study of several different metals and examined how far the electro-chemical theory of corrosion (usually called the electrolytic theory) could account for the observed phenomena. It was shown that this theory gave a satisfactory account of the facts only under certain conditions, and that many details could only be explained by recognising the important part played by colloids in corrosion. Chemical reactions may occur when the reacting bodies are in contact, and electro-chemical reactions when the reacting bodies are spatially separated. Pure electro-chemical action may in certain cases be relatively unimportant. Thus, the cathode of a cell of high voltage may be more rapidly attacked than the anode, while an anode at a high voltage tending to force it into solution may be very little corroded owing to scale formation. The order of corrodibility of metals in distilled water, certain salt solutions, and non-electrolytes was different from their order in the electro-chemical list, which suggested that there were factors interfering with the electro-chemical action. Such a factor was scale formation, and a main factor in determining the amount of corrosion by water and salt solutions was the nature and distribution of the products of corrosion. This might be far more important than any hypothetical distribution of cathodes and anodes in the metal. Potential differences between strained and unstrained portions of the same metal were usually very small, and unstrained (annealed) metal may corrode more rapidly than strained metal. The effect of strain was a minor and ephemeral factor in corrosion in neutral solutions. A trace of impurity appeared to assist local corrosion, but the amount of corrosion was not proportional to the amount of impurity. Minute pores in metal may give rise to local action, as had been shown by Seligman and Williams. On the electro-chemical theory, the action of oxygen was that of a depolariser. It could be shown, however, that atmospheric oxygen had very little depolarising power at ordinary temperatures. The main function of oxygen in corrosion was to oxidise directly the metal and also, in some cases the products of corrosion. The report developed a theory regarding the part played by colloids in corrosion; this was explained by a diagram exhibited by Dr. Bengough. In the course of his remarks Dr. Bengough paid tribute to the work carried out by two Italian scientists, Messrs. Traube-Mengarini and Scala, in 1909 and 1912, who had forestalled Dr. Friend in recognising that colloids played a part in corrosion.

Dr. Carpenter, who opened the discussion, stated that since the committee had commenced its work there had been two classes of reports, one that covered practical problems such as the corrosion of condenser tubes and the other which dealt with the broad aspect of corrosion. Condenser tubes were dealt with in three reports; the fourth one went outside that particular problem in an attempt to ascertain what corrosion is. The fifth report pointed to a return to practical work. Dr. Carpenter indicated that the Brass and Copper Tubes Association had increased their grant from 300*l.* to 500*l.* annually, which pointed to the fact that the committee's work was appreciated. The position in which the committee now stood was briefly indicated by the sub-title to the report before the meeting; this showed that the committee had been forced to get down to the question as to what corrosion was. The Department of Scientific Industrial Research gave their aid with pleasure. All this showed that the committee had now reached a stage where the value of the corrosion work undertaken was getting to be more and more recognised. He (the speaker) found the work of great interest and was greatly impressed with the value of its fundamental nature. The conclusions of the report would tend to point out that there was no solution to the corrosion problem, that no metal was really unoxidisable. He (the speaker) did not share that view, *i.e.*, that a solution would not be reached. The paper was a classical one in its attempt to focus the corrosion phenomena generally; it covered iron and its alloys, and the iron and steel industry, quite apart from the non-ferrous metal industry, would be very grateful for the information it contained. A new special feature was the action of the colloids and their influence upon corrosion. The report, also, contained many terms that were really new, terms which had to be learned. Dr. Carpenter found the paper a most important one on the subject, and one which would require time to make its importance felt. He paid tribute to Mr. Stuart's collaboration in the work.

Mr. U. R. Evans expressed satisfaction that the authors of the report laid stress on the physical character of the corrosion product in determining the persistence of corrosion. The oxide coat that generally existed upon aluminium was almost as good a protective covering as a layer of nickel or silver, but in other cases the corrosion product was loose and non-adherent and afforded no protection. Certain re-agents, notably chlorides, tended to loosen the product and prevented it from shielding the metal effectively. Their action seemed to be governed by the same universal physical principles as the action of soap in removing a grease film from metal. If soap was added to the water, the interfacial energy at the boundary between grease and soap solution was small and the removal of the grease from the surface in small globules into the soap solution involved no increase of energy and proceeded quite easily. Similarly, the oxide film existing on many metals was closely adherent when they were immersed in pure water, but if chlorides were added to the water the separation of the oxide from the metal involved no increase of interfacial energy and the corrosion product tended to be of a loose character. Hence the importance of chlorides in preventing the passivity of metals. If there was added to the liquid an agent capable of dissolving the corrosion product, the activity was increased still further. It was noteworthy that those metals which, like iron or nickel, had oxide soluble in acid and insoluble in alkali, tended to become active in the presence of acid and passive in the presence of alkali. Metals like tungsten or molybdenum, which had oxide soluble in alkali, but almost insoluble in acid, tended to become passive in an acid solution, but were rendered active in an alkaline solution. In considering the behaviour of the more reactive metals towards different aqueous reagents one was tempted to say that the insolubility of the hydro-oxide was the main determining factor. The only metals quickly attacked by pure water were those like sodium and potassium, which had soluble hydro-oxides, whereas metals like zinc and aluminium with hydro-oxides soluble in alkali were quickly attacked by caustic alkali, although other equally oxidisable metals like magnesium were scarcely attacked at all. Turning to the question of whether corrosion was chemical or electro-chemical, it would appear that since the atoms were certainly electrically charged in the combined state, corrosion was essentially a passage from the uncharged to the charged condition, and consequenly an electrical factor must be involved; in this sense even the so-called "direct chemical attack" was really electrical. The difference between this electro-chemical corrosion and direct chemical corrosion was that in the direct chemical type the metal would only be attacked at those points to which the oxidising agent, usually dissolved oxygen, had direct access; in the electro-chemical type corrosion might occur at places to which the oxidising agent had no access. It was clear, however, that corrosion often proceeded most rapidly at those points to which the dissolved oxygen had least access, as, for example, at the bottom of pits or where the metal was shielded by string, cotton wool, wax or permeable corrosion products. None of the chemical theories of pitting explained how the oxygen was at the bottom of a deep pit, whereas if corrosion was attributed to a difference of potential between the aërated and unaërated portions, it could be said that the metal entered the ionic state at the unaërated portion within the pit, forcing out upon the parts of the surface outside the pit, hydrogen which was removed by the oxygen there present. There was another line of argument which led in a logical manner to the conclusion that much of the corrosion met with in practice, and which the authors attributed mainly to chemical action, was to a great extent of the electro-chemical type. He was surprised that the authors laid so much stress upon the fact that the hydrogen produced by the action of water upon zinc was invisible even under the microscope. A similar phenomenon was met with if one considered the electrolysis of acidulated water in a cell fitted with platinum electrodes by means of an external E.M.F. If the E.M.F. applied was high, say, 2 volts, the electrodes became so super-saturated with oxygen and hydrogen that the gases were freely evolved in bubbles. If the experiment was repeated with a lower E.M.F., 1·2 volts, using fresh electrodes, a current passed producing at first oxygen and hydrogen at the electrodes; but before the supersaturation was such that bubbles could be evolved the back E.M.F. caused by these gases was nearly equal to 1·2 volts, and the current dropped almost to zero. There was no doubt about the existence of oxygen and hydrogen at the electrodes, but these gases were invisible, being dissolved in or absorbed upon the platinum. If the water contained dissolved oxygen, this would slowly remove the hydrogen from the polarised cathode, and just sufficient current would continue to flow to replenish this hydrogen. The depolarising action of the oxygen was slow, simply because it was limited by the rate at which dissolved oxygen could diffuse to the cathode surface; it was this diffusing rate and not the exact value of the E.M.F., which was applied to the cell and determined the amount of the small current which continued to flow through the cell. It should be noted that one of the products of the dissolved oxygen upon the cathodic hydrogen was hydrogen peroxide. Taking as an example the state of affairs on immersing impure zinc in acid the local currents caused the cathodic portions of the surface to become so supersaturated with hydrogen, that the gas was evolved in bubbles. But in neutral water the state of affairs was different. Here the hydrogen iron concentration was only one ten-millionth that in acid, and the hydrogen gas concentration produced at the cathodic portions would not become sufficiently high to allow evolution in bubbles. When a certain amount of hydrogen had collected at these places, the potential would become equal to that of the anodic portions and current would cease to flow. This hydrogen would be invisible. If, however, there was present

oxygen dissolved in the water, it slowly removed the hydrogen from the cathodic portions, and just sufficient zinc would pass into the combined state at the anodic portions to replace the hydrogen removed at the cathodic portions. One would expect that the depolarising action of oxygen would produce hydrogen peroxide, and it was significant that this body was generally met with in the corrosion of zinc, iron and aluminium by nearly neutral waters. A maximum rate of corrosion was clearly fixed by the diffusion rate of oxygen across the layer of liquid next to the metal. So long as the lack of uniformity of the metal was sufficient to replenish the hydrogen removed at this very slow rate, the exact degree of uniformity could have no influence on the rate of corrosion. It would be asked why oxygen should diffuse towards commercial spelter quicker than towards zinc, or why it should diffuse quicker towards cast than wrought-iron. Of course, in certain specially made material such as Lambert's iron, the uniformity must be such that the hydrogen was not produced so quickly as it was used up, but such materials were quite exceptional, and could not be obtained without taking special precautions. The different behaviour of the different metals was dictated not so much by their position in the potential series as by the solubility and physical character of the corrosion product. The action of non-oxidising acids upon re-active metals was governed by quite different laws because here the hydrogen was evolved in bubbles and the question of oxygen diffusing did not enter in. Accordingly, in dilute hydrochloric or sulphuric acid, cast-iron dissolved more quickly than the so-called open-hearth pure iron. The dissolution of metals in acid was much more rapid than in neutral solution, and this accorded rather better with the position of the metals in the potential series, but there was still one complicating factor, namely, that remarkable super-saturation phenomenon which was known to electro-chemists as over-voltage. Pure zinc was hardly ever attacked by acids, owing to its high over-voltage, but certain impurities and especially metals which were more noble than zinc, and which had low over-voltage values, had a remarkable accelerating action. Of course, they could only act as cathodic areas when present as a separate phase. If uniformly distributed in solid solution, they had no immediate influence. But all the noble impurities in zinc, whether present in solid solution or between the grains, appeared as a black scum on the surface of the metal as attack proceeded. This gave an explanation of the so-called period of induction observed in the corrosion of zinc. When zinc was first immersed in acid, the attack was slow, but as the black scum, consisting mainly of lead and cadmium, appeared on the surface, dissolution proceeded faster and faster. It was found that if the black scum was removed, the rate of attack dropped again. It would seem, therefore, that the difficulties raised by the authors largely disappeared when the matter was closely investigated. The authors had given a number of cases which they stated were difficult or impossible of explanation on the electro-chemical theory, but, it appeared to him (the speaker) that in none of those cases was an electro-chemical interpretation definitely excluded.

Mr. W. H. J. Vernon said that speaking as one who had defended the principles of the electrolytic theory he was glad to note that the present report while it placed limitations upon the scope of that theory gave it a bigger place than had been accorded to it in the fourth report of the committee. He still thought that the fourth report was rather too speculative in its findings, but he agreed that in the case of a metal immersed in the liquid in which the concentration of displaceable ions was relatively low and whose content of dissolved oxygen was relatively high, the conception of direct oxidation as advocated in the fourth report provided a reasonable explanation of the initiation of corrosion over at any rate a very wide range. The theory advanced in the present report filled in the breech with a very ingenious explanation which deserved most careful attention. It was interesting to note that the authors incorporated electrolytic phenomena as well as direct oxidation into their explanation of the initial action. He did not propose to discuss this theory, but would content himself with expressing the hope that it might ultimately meet with general acceptance. Incidentally, if this should prove to be the case, it was curious to reflect that the history of metallurgical controversy would be repeated. He referred to the old controversy between the carbonists and allotropists in connection with the theory of steel hardening which ended ultimately in the fusion of the two schools of thought. His main object in entering the discussion was to take the opportunity to put in a plea for the simplification of corrosion nomenclature the need for which no one familiar with corrosion literature would dispute. Excluding for the moment considerations of colloidal phenomena, it might fairly safely be said that the alternative in regard to initial action in aqueous solutions boiled down to two in number. Either the metal passed into solution in the ionic condition in virtue of its electrolytic solution tension, or the surface of the metal was attacked by molecular oxygen already present in solution. These two cases were exemplified in the report and the behaviour of the common products as indicated in the text followed readily from considerations of their mode of formation. To his mind it seemed highly desirable that the scheme of nomenclature should clearly differentiate between these two fundamental types of initial action. The authors had got the latter type safely fixed up, this constituting the direct oxidation dealt with in the fourth report. With regard to the former, however, they were not quite so certain, and preferred to place in a separate compartment those cases where the dissolution of the corroding metal was hastened by being coupled with an electro-negative material. This distinction was doubtless necessary from the purely physical point of view, on account of the electrical current which was thereby generated, but he failed to see the necessity from the point of view with which they were at present concerned. After all, corrosion would depend upon the solution tension of the dissolving metal, and in many cases the second element acted merely in virtue of its lower over-voltage facilitating the escape of displaced hydrogen. Regarding this type of action as a whole the authors had used the term "solution tension theory," and this would seem to be beyond criticism. On the other hand, the term "electrolytic" was in very common use, and personally he could see no objection to apply this term to any case where a metal passed into solution ionically, *i.e.*, in virtue of its solution tension. This suggestion would get rid of such terms as "acid theory"; "carbon dioxide theory," &c., with which unfortunately the literature of the subject abounded. These terms were frequently misleading, and at the best were merely redundant, and he thought the time had come when a serious attempt should be made to do away with them. Referring to the particular case of electrolytic action where there were definite anodes and cathodes which admittedly was the usual state of affairs where continuous corrosion was proceeding, the term "galvanic surface" was available. This term was in common use by chemical authorities, and for the present purpose seemed preferable to the term "electro-chemical," since the latter was very frequently used synonymously with electrolytic. With regard to the conception of partial separation he thought that in any case it should be emphasised that the separation might be upon a very small and even upon a molecular scale, so that approaching the matter another way cases were found where the distinction between the two types of electrolytic action broke down altogether. Turning to the question of colloidal phenomena, taking the report in conjunction with Traube-Menghavini's work, there appeared to be some doubt whether, strictly speaking, colloidal phenomena played a primary or a secondary part. Dr. Bengough's remarks that morning, however, had cleared the matter up, and he was very glad that an account of Traube-Menghavini's and Scala's work would appear in the report as finally published, as those workers had shown that colloidal solutions of all the common metals were obtained merely on immersion in water. He was also very interested to have their criticism of Traube-Menghavini's conclusion that oxygen was not necessary for colloidal solution. If that conclusion could have been substantiated it would at once have opened up the possibility that the absolutely initial action might after all consist in electrolytic solution. In this connection it might perhaps be mentioned that Whitney, as long since as 1903, in introducing his electrolytic theory of the corrosion of iron, stated that a colloidal solution of ferrous oxide was obtained in a very early stage of the action. Before closing his remarks he would like to refer back to the galvanic surface type of electrolytic action for the purpose of emphasising its importance in corrosion phenomena. While this action naturally had its greatest effect in acid liquids, it occurred quite frequently in neutral solutions. As an example of internal or local surface action it might be mentioned that certain alloys of zinc with tin and copper corroded rapidly in distilled water, and it might readily be arranged for the displaced H_2 to be collected. With regard to the external type of couple action very many examples could be quoted from practice. Some years ago legal action was taken over the wholesale damage due to iron ships in Leghorn Harbour through the presence of copper-bottom yachts, electrical connection being afforded through hawsers and buoys. The electrolytic theory was then vindicated to the extent that the copper-bottomed vessels had to be removed from the harbour. Coming to more recent times, a case was described last year before the American Electro-Chemical Society of a schooner cased with plates of monel metal. Contact of this metal with the steel rudder frame and other exposed steel parts took place and caused corrosion so rapidly that the ship was broken up without having made a single voyage.

In the course of his reply to the discussion, Mr. Stuart said he was interested in Mr. Evans's defence of the electro-chemical theory, but one point passed over was as to how the pacifying effects of the dichromate could be explained. The remaining part of his reply had reference to the diagrams exhibited. Dr. Bengough said he would deal further with the discussion by correspondence in the proceedings.

The Effect of Superheated Steam on Non-Ferrous Metals used in Locomotives.

The second paper taken on Wednesday was the one having the above title, by Sir Henry Fowler. It was not discussed. We reproduce it on page 374.

White Metals.

The third dealt with "White Metals," and was contributed by Mr. A. H. Mundey, Mr. C. C. Bisset and Mr. J. Cartland. It reviewed the manufacture and use of white metal for industrial purposes, and the composition, mechanical and physical properties of the chief alloys. It indicated also the appropriate alloys for particular purposes, and gave the effect of overheating and injudicious heating. The printing alloys were also entered into.

The discussion was opened by Sir Henry Fowler who said he was under the impression that for aeroplane work—aero-engines—the alloy was not the authors No. 1, having tin 93 per cent., antimony 3·5 per cent., and copper 3·5 per cent., but their No. 2 with 86 per cent. of tin, 10·5 per cent. of antimony, and 3·5 per cent. of copper. In locomotive work, where it was important to have a bearing metal which stood up to alternating pressures, the proportions were 85 per cent., 10 per cent. and 5 per cent., this was universally used for locomotives and other engines where there occurred repeated alternating pressures. The authors' No. 7 alloy having tin 20 per cent., antimony 15 per cent., copper 1·5 per cent., lead 63·5 per cent. was also used, but the Brinell hardness was lower than the figure given by the authors. If there were no change in the stress this was a very satisfactory metal. He (the speaker) also questioned the Brinell number 24·9 for the authors' No. 9 alloy having tin 5 per cent., antimony 15 per cent., and lead 80 per cent.; the Brinell hardness number was lower. He had also had experience with the cuboïd crystals found by the authors; there was formed an eutectic space in which the oil might lie. These crystals stood high, were hard, the eutectic melted and resulted in hot bearings.

Dr. Rosenhain, who followed, said that the question of white metal manufacture had received less attention than it should have done, and the

authors' account of practical manufacture of such metals was a welcome contribution. It covered a wide field. He confirmed the last speaker's remarks on the alloy 85, 10, 5 for aircraft generally. As regarded the behaviour of these metals under alternating pressures, Sir Henry Fowler's remarks were important. As to why a particular alloy was better than another, there was not sufficient systematic knowledge to show. Little was known as to the metal strength in resisting alternating stress or shock. For type metal, resistance to abrasion came in as well. The variations in the properties following upon changes in the composition were as yet insufficiently known. The paper would have greatly gained by dealing also with the question of white metals for die-castings. He (the speaker) doubted the "oil channel" formed in the body of bearings. There was, further, no appreciable difference of level between the hard and the soft surfaces. The crystals were supported in a plastic matrix, and very probably a film of softer substance flowed over the harder and acted as a lubricant, forming a colloid of oil and softer metal. Here, Dr. Rosenhain called attention to the recent work on the theory of lubrication.

In the course of his reply, Mr. Mundey said the paper was an attempt to show what was done at Fry's Metal Foundry, and they expected to be taken to task in the matter of distribution of the oil film and the remarks as to the irregularity of the structure. Sir Henry Fowler expressed his surprise at No. 1 alloy being stated as used for aero-engines. Mr. Bissett, one of the contributors to the paper, acted during the war as an inspection officer in the Air Department, and had had much experience in the subject. They had, perhaps, overstretched the point and had given it undue prominence. The alloy No. 2 being harder, they hesitated to use it when subject to alternating and irregular stresses, hammering stresses. They had no doubt concerning the Brinell hardness numbers they quoted. The paper dealt with representative metals which were actually in use, and tests upon them were accurate, and the manufacture of all the metals was carried out under the same conditions of temperature, pouring, and so forth. The figures of physical tests quoted were given so that the engineers could visualise the conditions of the metals they were using. He would deal by correspondence with the question of resistance to abrasion. The subject of die-casting was at first in the paper, but owing to length this had to be cut out and will be dealt with in a further contribution. The subject is a difficult one, since it is difficult for an article of intricate shape to design a tool that will cut it, and to have a metal that will exactly flow.

GRAIN-SIZE AND DIFFUSION.

The fourth paper on the list for Wednesday, on "Grain-Size and Diffusion," by Professor J. H. Andrew and Mr. Robert Higgins, was taken as read, and will be discussed by correspondence in the Institute's proceedings.

(To be continued.)

LITERATURE.

Waterworks for Urban and Rural Districts. With notes on the supply for Mansions and Isolated Buildings. By HENRY C. ADAMS, Consulting Engineer. London: Sir Isaac Pitman and Sons, Limited, 1922. [Price, 15*s.* net.]

THIS book provides a general description of the appliances in ordinary use, for collecting and distributing an adequate supply of potable water, suitable to small and moderate schemes, and if we recall the various sources of supply, the provision of physical, chemical and bacterial tests, the character of the impurities likely to be found, the necessity and the means for eliminating these, the methods of sterilisation and softening, the collection in bulk and the final distribution to the house occupier, all of which topics and many others come under review, it will be understood that the treatment is necessarily somewhat superficial. The author in designing his book to assist students preparing for examination, has endeavoured to cover a wide ground, and his success must be judged by results. His plan appears to have been to collect and classify the examination questions that have been set by various boards of examiners, and to write a treatise that shall give the information necessary to answer the questions set. The adoption of this plan indicates the limits the author has imposed on himself.

In the early chapters are discussed the sources of water supply as derived from rainfall, the effects produced on the precipitation by the various geological strata through which the water percolates, and the formations that give rise to springs and make the sinking of wells feasible. The quantity required per head and the degree of purity of water attainable lead to the discussion of the possibility of collecting sufficient rain water from roofs and buildings to supply the inmates of isolated dwellings. To the town dweller such problems do not appeal, his interests are limited to the consideration of the relative advantages of a continual or an intermittent supply, but to a population scattered over a wide area, where house to house distribution is difficult and expensive, such propositions become of vital importance, and in a book of this character addressed quite as much to the amateur as the expert, the consideration of the limits of such an installation and the precautions to be taken to ensure the necessary purity, are fitting and expedient. It is easy to indulge in a policy of perfection against pollution, and to urge the merits of thorough and effective chemical treatment, without regard to the difficulties of its application, if it is to be made a safeguard against water-borne disease. The author adopts a wiser and more modest course. He points out the advantages and explains the construction of a mechanical separator, that prevents the storage tank being made a receptacle for all the dust and soot collected on the roof. A practical form of filter is also suggested, that would prove effective in ensuring a supply of water suitable for dietetic purposes.

In further connection with supply to a widely scattered population, the sinking of wells and of boreholes receives attention, leading to the subject of hand and mechanical pumping. Here we think the author loses his way in some measure. The discussion of mechanical power and the introduction of formulæ without explaining the method of their derivation may puzzle the student without advancing the subject, while the devices of pumping machinery are so many and so various in design, that the details cannot be adequately treated in the few pages allotted to the topic. Among forms of pumping now generally discredited in competition with more certain and constant sources of power, the utilisation of windmills is advocated as a practicable and economic method of raising water from wells to supply small schemes. An example is given in which power derived from a 40-ft. self-regulating geared wind engine, erected on a steel tower 40 ft. high, develops 6-h.p. with a 15-mile wind per hour, and raises 3,000 gallons of water per hour. This quantity is found sufficient to supply a population of 1,200 at 20 galls. per head per day.

Passing over such technical subjects as steam and river gauging, the construction of dams and the provision of impounding reservoirs, which lie outside the purview of an elementary work, the subject of purification is introduced and a quantity of concise and useful information is provided, that should prove useful to those who have charge of chemical plant for the removal of impurities. The general method described is that of storage coupled with slow sand filtration, in which the water passes through a series of filters, filled with material varying in size from coarse gravel to fine sand, the main work of purification being affected by nitrifying organisms in the body of the sand. Mechanical filters are recommended for the removal of oxidizable material, and are to be preferred, if there is a risk of the water finding a weak place in the sand bed and can pass in a defined channel to an outlet in an unpurified state. Types of purifying plants are well described. These include rapid filters of the gravity or pressure type, roughing filters for the preliminary treatment of water before passing on to slow sand beds, coagulating and sterilising gear for the treatment of water under gravity and pressure, softening plant, and plant for the removal of iron, algæ and special impurities.

The usual methods of chlorinating water by the addition of bleaching powder or the injection of chlorine gas for the elimination of pathogenic bacteria are treated with some fullness and evidently give the results of much accumulated experience. The author states that gaseous chlorine affects the taste of the water in a less marked manner than does bleaching powder, but this is questioned from many quarters, and it is said that the sulphur dioxide recommended for de-chlorinating purposes is in some cases absolutely without effect on the taste qualities. Probably, where inefficacious, the taste arises from other causes than the presence of chlorine, and cannot be destroyed by the formation of chlorides and sulphates which it is the purpose of the sulphur dioxide to bring about. We are glad to notice a reference to Houston's excess lime method of sterilisation, and the use of such substances as Permutit and Chabasite for softening.

The book concludes with some chapters giving sound instruction on the distribution of water by service mains, describing the necessary fittings, on fire protection, on water meters and waste detection with other matters that affect the comfort and the welfare of domestic life. To technical students this collection of facts should be of great service, while the agreeable method in which they are presented and the excellent illustrations by which they are accompanied, enhance their value in no small degree.

BOOKS RECEIVED.

British Empire Patent Conference, 1922. Report of the Conference held at the Patent Office, London, from June 12, 1922, to June 23, 1922. London: His Majesty's Stationery Office. [Price 1*s.* net.]

Income Tax and Super-Tax, 1842–1923. Tabular View of Rates, Allowances, &c. London: Oliver and Boyd. [Price 1*s.*]

Air Ministry. Civil Aviation Advisory Board. First Report on Imperial Air Mail Services. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 1*s.* net.]

Filtration. An Elementary Treatise on Industrial Methods and Equipment for the Filtration of Liquids and Gases. By T. ROLAND WOLLASTON. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

Essais de Soudures Autogène et Électrique de pièces de Chaudières. Par E. HOEHN. Paris: Ch. Béranger. [Price 4 francs.]

Tolley's Complete Income Tax, Excess Profits Duty, Corporation Profits Tax, Super-Tax, &c., Chart. Seventh edition. London: Waterlow and Sons, Limited. [Price (including supplement) 2*s.* 6*d.* net.]

Tolley's Income Tax Tables for 1920–22 and 1922–23. London: Waterlow and Sons, Limited. [Price 1*s.* 6*d.*]

Machine Tool Operation. Part II. *Drilling Machine, Shaper and Planer, Milling and Grinding Machines, Spur Gears and Bevel Gears.* By HENRY D. BURGHARDT. New York and London: McGraw-Hill Book Company, Inc. [Price 13*s.* 9*d.* net.]

THE LATE MR. L. H. WALTER, M.A.—It is with sincere regret that we announce the death of Mr. Louis Heathcote Walter, editor of *Science Abstracts*, and a well-known worker, especially in the field of radiotelegraphy. Born in London in 1870, he was educated privately; he went to Hanover before proceeding to Trinity College, Cambridge, in 1894, where he took the Natural Science Tripos in 1898. Having conducted research work in the University Engineering Laboratory, he joined the Institution of Electrical Engineers and the Institution of Civil Engineers as associate member, and was for some time experimental assistant to Sir Hiram Maxim. He then became interested in directive radiotelegraphy, associated himself in 1907 with Dr. Bellini and Captain Tosi, and introduced their system into England; these rights were subsequently acquired by Marconi's company. Already, in 1903, when the Institution of Electrical Engineers had taken over the management of *Science Abstracts*, he had been appointed editor of that exceedingly useful publication; his predecessors in that position were Mr. J. Swinburne and Mr. W. R. Cooper. He was also indexer in Physics for the International Catalogue of Scientific Literature and found time, in spite of his onerous duties, to revise the volumes on Electrical Engineering and on Steam and Internal Combustion Engines of the Deinhardt-Schlomann Technical Dictionaries, to write a book on "Direction and Position Finding" in 1921, and to contribute various scientific papers to the Institution of Electrical Engineers, the Royal Society and other bodies. Prominent among his researches and discoveries were a selective system of wireless control, various detectors and coherers, researches on increase of hysteresis loss due to oscillations superposed on a rotating field, on self-restoring detector action of a tantalum-mercury contact, and on electrolytic valve effects, especially with tungsten and zirconium electrodes. His oscillation galvanometer brought him the John Scott medal in 1907. Mr. Walter married a daughter of the late Captain Edward Williams in 1900. He was a man of reserved disposition. He died after a very short illness of endocarditis, on September 13, and leaves a gap among friends and colleagues difficult to fill.

BOILER DEPARTMENT AT ELSWICK WORKS.

THE boiler department of Sir W. G. Armstrong, Whitworth and Co., Limited, is situated at the east end of the Elswick Works at Newcastle, close to the old shipyard and parallel with the river Tyne. The buildings are modern in every respect, well lighted both naturally and artificially, and heated and ventilated in such a manner as to enable the work to be carried out under efficient and comfortable conditions. The main shop is in three bays, all under one roof, and together with its subsidiary shops it covers a floor space of 16,000 sq. yards. Figs. 1 and 2, on page 366, give a good idea of the general lay-out and construction of the main shop, the illustrations showing the appearance of two adjacent bays. The plant and organisation is such that the department is easily producing 50 main line locomotive boilers per month, and at the present time finds employment for 1,000 men.

The whole lay-out has been devised with a view to boiler production on the most efficient lines. The material follows a steady course through the shops and past the various machines in order, never zigzagging or returning on its path until it finally arrives at the testing pits in the form of finished boilers. An equipment of 20 overhead electric cranes facilitates quick handling and transportation of the plates and other details. The machine tools number over 200, all of the latest types employed in locomotive boiler manufacture. The battery of boiler-shell drilling machines and the hydraulic flanging presses were made by the machine tool department of Messrs. Armstrong, at the company's Openshaw works. The flanging presses work in conjunction with incandescent furnaces and electric charging machines, the equipment being sufficiently powerful to enable the very largest Belpaire throat plates to be flanged in a single heat. There are also four large hydraulic riveting machines, for shell work, one of these machines having a gap of 27 ft. In the smithy section another powerful press is installed for the welding of fire-box foundation rings and similar work.

Compressed air is laid on everywhere throughout the shops and is utilised for riveting, caulking, drilling, tapping and chipping. All the pneumatic tools employed are of Messrs. Sir W. G. Armstrong, Whitworth and Co.'s own design and manufacture, and special devices are used for supporting the tools conveniently when at work. It is needless to remark that gauges, jigs and templates are used to the fullest possible extent to ensure accurate and interchangeable work, so that all unnecessary adjustment of pipes, &c., is done away with when the boiler has been placed in the engine framing. The testing pits provide for the testing of four boilers simultaneously, and underground flues carry away the smoke and products of combustion to a chimney outside the shop, so that the air within is not fouled. The testing pits are within a couple of hundred yards of a deep-water jetty where the largest ocean-going steamers can be berthed. The jetty is equipped with a hydraulic crane capable of handling loads up to 150 tons, so that the boiler department is excellently situated as regards convenience for overseas shipment. Its transport facilities in other respects are also particularly good, as there are roadways and railways giving access to all parts of the works.

INDUSTRIAL NOTES.

THE Ministry of Labour state that employment during August remained bad, and the improvement which had been in progress since the beginning of the year was not maintained at the same rate as in previous months. There was a marked improvement, however, in the coal-mining industry, and some improvement was reported in the pig-iron industry and in iron and steel manufacture. The percentage unemployed among members of trade unions from which returns are received was 14·4 at the end of August, as compared with 14·6 at the end of July and 16·3 at the end of August, 1921. The percentage unemployed among workpeople insured under the Unemployment Insurance Act (Great Britain and Northern Ireland) was 12·0 on August 21, as compared with 12·3 on July 24. The total number of workpeople registered at the Employment Exchanges as unemployed on August 28 was approximately 1,378,000, of whom 1,121,000 were men and 173,000 were women, the remainder being boys and girls. At the end of July the number on the live register was 1,400,000, of whom 1,151,000 were men and 170,000 were women. The number of vacancies notified by employers to Exchanges and unfilled on August 28 was 12,700, of which 3,000 were for men and 8,000 for women, compared with 14,100 at July 31.

The Ministry of Labour announces that the number of unemployed persons on the live registers of the employment exchanges in Great Britain on September 11 was 1,318,500. This was 9,512 less than in the preceding week and 505,233 less than the figures recorded at the beginning of last January. The number working short time and drawing benefit for intervals of unemployment was 60,800 on September 11, compared with 61,529 on September 4 and 934,786 on July 1, 1921.

In the industries for which statistics are collected by the Labour Department the changes in rates of wages reported as having taken effect in August resulted in an aggregate reduction of about 450,000*l.* in the weekly full-time wages of over 2,000,000 workpeople, and in an increase of 15,000*l.* in the weekly wages of over 90,000 workpeople. The principal bodies of workpeople affected were coal miners in Durham, Yorkshire and the East Midlands, workpeople employed in the engineering industry, and gas workers. In the case of coal miners there were decreases equivalent to rather less than 1 per cent. on current rates in Durham, and to over 14 per cent. in Yorkshire and the East Midlands. On the other hand, the lower paid day-wage workers in coal mines in Lancashire, Cheshire and North Staffordshire received increases up to 1*s.* per shift in the form of subsistence allowances. Men in the engineering industry had their rates reduced by 5*s.* 6*d.* per week, and those in the gas industry by ½*d.* per hour or 4*d.* per shift. Other groups of workpeople who sustained reductions included steel smelters, iron puddlers and millmen in the Midlands, brass workers at Birmingham, coal trimmers, letterpress printers in provincial towns in England and Wales, workpeople engaged on civil engineering work, and in the cement industries. Since the beginning of 1922 the changes in rates of wages reported to the Department have resulted in a net reduction of over 3,600,000*l.* in the wages of 7,500,000 workpeople, and a net increase of nearly 3,500*l.* in the wages of 18,000 workpeople.

The number of trade disputes involving stoppages of work, reported to the Labour Department as beginning in August, was 32. In addition, 35 disputes which began before August were still in progress at the beginning of the month. The total number of workpeople involved in all disputes in August (including those workpeople thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was about 31,000, as compared with 46,000 in the previous month and 40,000 in August, 1921. The estimated aggregate duration of all disputes during August was about 310,000 working days, as compared with nearly 450,000 days in July, 1922, and 460,000 days in August, 1921. Since the beginning of 1922 the stoppages of work, owing to trade disputes, reported to the department have involved approximately 500,000 workpeople, as compared with nearly 1,750,000 workpeople in the same period of 1921. The aggregate duration of the stoppages in 1922 has been nearly 20,000,000 working days, compared with 85,000,000 days in the corresponding period of 1921.

On September 1 the average level of retail prices of all the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel, light, and miscellaneous items) was about 79 per cent. above that of July, 1914, as compared with 81 per cent. at August 1.

Speaking last Saturday at a conference of the Industrial League and Council, Mr. E. W. Petter, managing director of Messrs. Vickers-Petters, Limited, Ipswich, said that one of the worst effects in this country of industrial strife had been to alienate the workers from solicitude as to the well-being of their industries. He added that if all parties were to rally around a policy of determination to guard the industries of the country they would be a long way on the road to better things. The most important effect the war had had on international trade was that it had driven agricultural and producing countries into becoming manufacturing and industrial communities. Australia and India were developing manufacturing industries, and India was developing a great iron and steel industry.

The monthly report of the United Society of Boilermakers and Iron and Steel Shipbuilders, may always be relied on to include a curious and characteristic contribution by Mr. John Hill. In the September issue his plea appears to be that because certain shipbuilding firms made large profits in the past, they should be now content to dissipate these in building ships below cost, thus maintaining existing rates of wages. Not unnaturally the history of the Northumberland Shipbuilding Company has been made to serve as a text, but in stating that the capital was 7,000,000*l.* and the average dividend 12½ per cent., he neglects to state how much of the capital received this dividend, though, in subsequently treating of the Irvine Shipbuilding Company, he shows clearly that he recognises a difference between ordinary and preference shares. He asserts that 8 per cent. on preference shares is too large a return, but considering that municipalities have had to raise money at 6 per cent., the extra 2 per cent. does not seem extravagant in view of the additional risk attaching to industrial undertakings. The concluding portion of his remarks include a well deserved eulogy of Henry Ford, but in pointing out that Mr. Ford has succeeded in combining high wages with low production costs and urging our own employers to follow this example, Mr. Hill guards himself by remarking that he does not commend all his methods. Details as to these are omitted, but one may be pretty certain that the feature most repugnant to Mr. Hill would be Mr. Ford's claim to full managerial control, which alone has made possible the results he has achieved. As has often been pointed out in these columns, high wages are not incompatible with low production costs, provided the management is capable and allowed a free hand without restrictions by the so-called "hard won rights and privileges" achieved by the trade unions. These latter are quite incompatible with such prosperity as that attained by the Ford employees.

As was expected the tramwaymen are strongly averse to accepting the proposals of the Municipal Tramways' Association to terminate the sliding scale agreement and to reduce wages by three successive instalments of 4*s.* a week. The reasonableness or the reverse of this proposal cannot, of course, be settled by the *a priori* methods of the speakers at the conference of the Transport and General Workers' Union held in London last Tuesday. The tramwaymen are entitled to such a wage rate as is received by men of corresponding ability and skill in other departments of industry working similar hours, and are not entitled because of the quasi-monopoly character of their employment to exact a higher rate than this. To make the attempt is morally on all fours with the formation of a wheat corner. Any excess over such a just rate must be wrung from the fares paid by men, who would, in such case, be worse off than themselves. A proposal has been made to arbitrate the matter, but it has not been accepted.

Notices have been posted at the Coventry works of the English Electric Company, Limited, stating that they will be closed next month, the directors having decided to concentrate on their Bradford, Preston, Stafford and Rugby factories, owing to lack of foreign orders and the general state of the home trade. The staff and foremen are transferred, but 800 other workers will be out of employment. The company will re-open the works when the volume of business justifies the step. In normal pre-war times some 2,500 men were employed here.

Ballot papers on the proposed wage reduction have been printed by the Federation of Shipbuilding and Engineering Trades, and were issued on Monday to the shipyard members of the unions affiliated to the Federation. The ballot paper puts three questions: (1) For acceptance of employers' proposals; (2) For resisting the employers' proposals by a strike; (3) For empowering your representatives to make the best terms possible to be subject to a further vote. The ballot papers are returnable by October 5, and the vote is to be a pooled one. Attention is drawn to the fact that a two-thirds majority is required before a stoppage can take place. The employers' proposals are to withdraw the remaining 10*s.* of the war bonus of 26*s.* 6*d.* a week on November 1, except in the case of the lower paid workers, whose wages are to be the subject of further negotiations, but are not likely to be reduced below 37*s.* 6*d.* a week. The adjourned conference between the representatives of the Shipbuilding Employers' Federation and the shipyard trade union will be held at Edinburgh on October 10, when it is understood the question of stabilisation will be considered.

"MECHANICAL TRANSPORT."—We welcome a journal edited and printed in Russian in London, entitled *Mechanical Transport*. The first issue, for last July, contains articles on motor lorries, Diesel engines for motor vehicles, motorships, gas producer plants, electrical transmission and traction, aviation, roads, tractors, &c. The offices are at 88, Bishopsgate, London, E.C. 2.

THE BIRMINGHAM METALLURGICAL SOCIETY (INCORPORATED).—The opening meeting of the session of this society will be held at the Chamber of Commerce, Birmingham, on Wednesday evening, October 4, at 7.15 p.m., when the new president, Mr. A. J. G. Smout, M.I.M.M., A.I.C., will deliver his inaugural address on "Waste and Inefficiency in the Metal Industry." This will be followed at regular intervals to the end of April with papers by some of the leading authorities in the iron and steel and metal industries. Copies of the syllabus will be issued in due course, and may be obtained on application to the Secretary of the Society, Chamber of Commerce Buildings, Birmingham.

THE EFFECT OF SUPERHEATED STEAM ON NON-FERROUS METALS USED IN LOCOMOTIVES.*

By Sir HENRY FOWLER, K.B.E., Member.

At the time when Mr. George Hughes† read his very full and comprehensive paper on non-ferrous metals in locomotives, superheated steam was not employed to any great extent. Since that time its use has very much extended, and now it may be said that no new locomotive is built without being arranged to use superheated steam. The temperature of the steam as it leaves the superheater is usually about 340 deg. C. It must not, however, be taken that the various parts of the mechanism which are referred to in this note are all constantly at this temperature, because the steam in contact with some of them is expanded, with a resulting considerable fall in temperature.

The following is the experience and practice with regard to the chief parts that are subjected to superheated steam in the case of superheated locomotives on the Midland Railway.

Piston Tail Rod Bushes.—These are the bushes through which the tail rods of the pistons slide, and thus support is given to the piston. The tail rods are 2¾ in. in diameter, the bush being 7 in. long and ¾ in. in thickness. The tail rod is enclosed in a casing which is open to the cylinder. The bush is smaller in diameter than the inside of the casing for about 6 in. of its length, and therefore has a space round most of its outer surface. The flange at the cylinder end and a portion of the bush which extends into the case are exposed to the superheated steam during one stroke, and to exhaust temperature on the return. Originally these bushes were made of M.R.A.1 gun-metal, having the following composition :—

	Per Cent.
Copper	87
Tin	9
Zinc	2
Lead	2

This metal was found to break in service, but unfortunately as this was some years ago none is now available, and no photomicrograph was taken.

The gun-metal was replaced by cast-iron, which however was found to score the rods. Recourse was then made to a phosphor-bronze of the following composition :

	Per Cent.
Copper	88
Tin	11
Phosphorus	1

and this has been running for over six years in a number of engines with satisfaction.

Piston Rod Packing.—At the other end of the cylinder is fitted a gland of the U.K. type of metallic packing containing what are known as McNamee rings. The McNamee rings are two thin rings lying side by side in a case which does not touch the rod itself. The rings are in halves, and on their outer surface have grooves in which spiral springs are placed to keep them together and close on to the rod. The objects of these rings is to prevent the steam coming directly in contact with the white metal in the gland proper. From analysis the composition of the metal of which the rings are made appears to be as follows :—

	Per Cent.
Copper	75·5
Tin	8·5
Zinc	0·33
Phosphorus	trace
Nickel	0·5
Lead	15·0

With the exception of the above and the white metal packing rings, all the parts of the gland are made of gun-metal alloy. The white metal packing rings are of the following composition :—

	Per Cent.
Lead	70·0
Antimony	30·0

This has been found more satisfactory under the conditions used than the usual 80 : 20 lead-antimony alloy. The 70 : 30 mixture is cast roughly into the shape of the rings in open-top iron moulds, care being taken to see that the casting temperature is between 425 deg. and 450 deg. C.

During solidification the metal is pressed into the mould by means of a flat piece of wood, as this has been found to give metal of greater soundness. The fracture of this metal is coarsely crystalline, and its microstructure is shown by Figs. 1 and 2, annexed.

An interesting point about this metal is that although it has worked for about twelve years and gave the utmost satisfaction, apparently the temperatures met with, say, 340 deg. to 370 deg. C., are approaching its critical point, as an increase above this figure has been found to cause trouble. This was experienced during the coal strike of last year when a number of engines were fired with oil in place of coal, which was found to give a higher degree of superheat, the temperature rising to 425 deg. C. The trouble experienced was due to the packing rings fusing. It will be appreciated that the full heat is only on these parts intermittently.

Piston Valve Fittings.—The valve spindle packings are similar in design to those for the piston rods but of a smaller size, and the same metals are used throughout satisfactorily, although in this case they are subjected to superheated steam during the whole of the time the engine is working. The bushes for the ends of the valve spindles are made of M.R.A.1 alloy, which has been found to give satisfactory results. This is interesting in the light of the experience referred to above with regard to bushes for the piston tail rods.

The nuts which secure the valve heads to the spindles are of the M.R.A.1 alloy already given, and are satisfactory ; there is, of course, no work on them.

Cylinder Relief Valves.—These are placed at each end of the cylinder, and are made of M.R.A.1 alloy.

By-Pass Valves.—These valves, which are arranged to close communication between the ends of the cylinder when steaming, are subject to a good deal of shock, and of course to the temperature of the steam in the cylinders.

Originally they were made of good quality cast-iron, but it was found that the wings were liable to break.

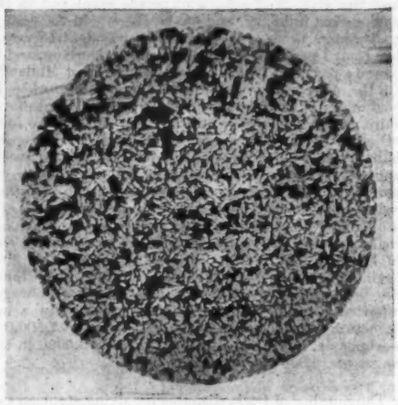


FIG. 1. MICRO. 1897. PISTON-ROD PACKING. 70/30 LEAD-ANTIMONY ALLOY, ETCHED WITH NITRIC ACID. 50 DIAMETERS.

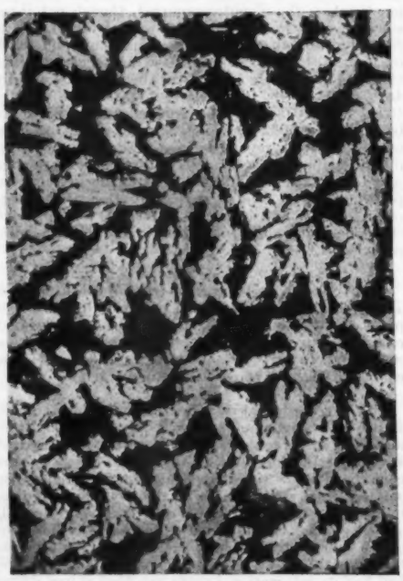


FIG. 2. MICRO. 1898. PISTON-ROD PACKING. 70/30 LEAD-ANTIMONY ALLOY, ETCHED WITH NITRIC ACID. 50 DIAMETERS.

Gun-metal of the M.R.A.1 gun-metal alloy and phosphor-bronze of the compositions referred to previously for tail-rod bushes were tried, but it was found that neither of these metals would withstand the service demanded. A complex nickel-brass having the following composition :

	Per Cent.
Copper	53·86
Tin	0·88
Lead	0·43
Aluminium	0·38
Iron	2·31
Manganese	0·84
Nickel	3·33
Zinc	38·05

was then tried with successful results, but on the question of cost was replaced by malleable iron or steel castings.

These are the chief parts used in a locomotive that are subjected to superheated steam, and it would seem from the experience above recorded that a metal which may prove satisfactory when not subjected to friction, may be wholly unsuitable when it has a moving part working over it.

* Paper read at the meeting of the Institute of Metals, Swansea, on Wednesday, September 20, 1922.

† ENGINEERING, vol. xcii, pages 393, 399, 433.

THE PROPELLING MACHINERY OF THE CARGO CARRIER OF THE FUTURE.*

By JAMES RICHARDSON, B.Sc., M.Inst.C.E.

THE one pressing necessity to-day is the revitalising of industry, and in this process, the mercantile marine with its cargo carriers acts as the connecting link. When considering the question of cargo ships, the actual design of the ship, in respect of its dimensions and the general features of the hull, is more or less definitely prescribed by the speed, the cargo to be carried and handled, and the docks and harbours to be used by the vessel. It is not so, however, except so far as speed is concerned, with the propelling machinery. At no time in the history of marine propulsion have so many types been available to the ship owner, from which to choose. Nor is the problem of selection a matter of easy solution. Not only is the propelling and deck machinery of great importance as regards first cost representing from 25 per cent. to 40 per cent. of the total cost of the ship according to the design of ship, type of machinery, and the dividing line which is adopted as between propelling and deck machinery, but the economy and certainty of operation of this propelling machinery is a dominant factor in governing the margin between profit and loss.

The ship owners of the sea-going nations of the world are now faced with the necessity of increasing tonnage, although the total tonnage to-day available is generally in excess, certain classes being excepted, of the freight-carrying demands ; yet the figures, which have recently and frequently been produced are misleading if taken at their face value. During the war, a considerable number of ships were pressed into services for which they were definitely unsuitable. Large additions of tonnage were also made in certain quarters without there being available either the requisite experience in construction or the necessary skill to manage the business side of ship owning and to operate the imperfectly constructed vessels. Furthermore, a number of the large ship-owning concerns with well-established trades of long standing, having all the necessary organisation for carrying on their special business, are operating with fleets of diminished numbers of ships of a greater average age than is consistent with maximum efficiency. In one case a fleet, the average age of which for maximum efficiency should not exceed 6 years, are operating with ships of 12 years old as the average. A further fleet, the normal complement of which is 16 ships is only now composed of 6. These are merely given as typical examples. The latest official returns show that of all the vessels owned in the world 31·5 per cent. are over 20 years old and more than 20 per cent. are over 25 years old. As regards British ships the position is substantially the same. All these factors can only lead to the definite conclusion that there certainly must be a considerable amount of building of new tonnage in the near future.

The question, therefore, of the type of ship, as denoted by propelling machinery, naturally arises and in this connection a decision must be made regarding the fuel to be used, whether oil or coal. At sea, oil has proved to be the fuel *par excellence*. The improved conditions made possible with steam ships by the substitution of oil for coal are revolutionary, and for certain classes of steam ships and on certain routes, such as liners on the Transatlantic service, the savings due to oil fuel by way of greater speed of ship, less delays taking fuel on board enabling a greater number of voyages to be made per annum, and the great reduction in the stoke-hold personnel, have made oil fuel the standard, even although the actual cost of fuel per trip is considerably greater with oil than with coal.

What of the average cargo carrier ? It can now definitely be stated that except in special cases the burning of oil fuel under boilers with the present prices ruling for coal and oil, is actually uneconomical. The advantages which hold in the case of the Atlantic liner have not now, with reduced wages, sufficient potency with the lesser powered and slower cargo carrier to warrant the extra first cost of machinery and the higher price for fuel. The subjects of price, distribution and available supplies of oil fuel must be considered. As regards distribution little difficulty will now be encountered because oil fuel stations in numbers have been provided on all of the principle trade routes, and the ease with which this fuel can be accommodated on board ship and the 50 per cent. greater heat value per ton and 65 per cent. advantage per cubic foot makes possible for a given ship a very much greater radius of action, without rebunkering.

The price of oil fuel within the last 10 years has kept approximately the same position relative to coal, with an inclination recently, to be relatively cheaper. There is no sign of a reduction to such a figure that oil-burning under boilers for the average merchantman can compete with coal, excepting in very special cases where oil is relatively very cheap and coal dear. There is evidence that there will be available supplies of fuel oil to meet the demand, although the incentive of the high prices obtainable for petrols and lubricating oils will tend to cause producers to distill the crude oils to the maximum possible extent, having the effect of lowering the quality of Diesel and fuel oils coming on the market.

Recently a number of tests ashore, followed up by

* Paper read before Section G of the British Association at Hull, September 12, 1922.

actual trials under normal operating conditions at sea, have proved that the Diesel oil engine is not so sensitive to varying qualities of fuel oil, including high asphaltic bunker oils, as was earlier believed to be the case. As to whether the extra overhauling which the heavier and less easily combustible oils may well demand, counterbalances the savings in fuel costs, will emerge in time, but it is certain that the capacity to burn reasonably satisfactorily almost any grade of fuel oil in the market is unquestionably an added asset of considerable value, and will in the future be regarded as a necessity for ocean-going tramps.

Mention should be made of the recent developments of the Anglo-Persian oil group towards securing an all-British supply of fuel oil for the needs of the Empire, with their great plant at Swansea for distillation and refining. The effect of this enterprise should be in the direction of assuring supplies and reducing the price.

Under such conditions as the foregoing, undoubtedly the Diesel oil engine, as the most economical consumer of liquid fuel, makes a most compelling appeal, requiring only from one-third to one-fifth the quantity of fuel used by equally powered steamers. The higher the power of the steamer the less favourable the case for the Diesel machinery on the score of fuel economy, but the fractions given will be found to be accurate when comparison is limited to equal powers.

There is also a fascination in the thought that instead of there being any transformation of energy as with steam plant, the heat contents of the fuel are utilised by combustion actually within the engine itself, heating the air of the Diesel cycle, which on expanding directly produces energy at the propeller. Such simple thermo-dynamical change, resulting in three times the thermal efficiency of the steam cycle and direct application of the process of combustion will prevail.

The present position of the Diesel engine is gradually but surely strengthening. There are now available more types of marine propelling plant of all kinds, and particularly of Diesel engines, than ever previously. Hitherto a reasonably full measure of success has been limited to those types of internal combustion machinery where conservatism in design and construction has been the key-note, but to-day newer developments on a bolder scale in internal combustion are gradually proving themselves at sea.

The Diesel engine recently has been thrown further into very strong relief by the troubles which have been experienced with double-reduction gearing. The maximum powers for which the Diesel engine can definitely be stated to be suitable are gradually increasing, and to-day 300 b.h.p. per cylinder, with 16 cylinders, *i.e.*, two engines each of eight cylinders, a total of 4,800 b.h.p. or the equivalent of 5,500 steam indicated horse power total is the standard for the larger class of motor vessel. This range of power covers 96 per cent, in numbers and 88 per cent. in tonnage of ships under construction at the present time, and whilst making all allowances for the fact that the average to-day may give a smaller ship than normal, due to the limited number of large liners under construction, yet, it is seen that the field already covered as regards power is very considerable. Such powers as 5,500 equivalent steam i.h.p. still require twin screws with the Diesel engine. This aspect will be dealt with later.

The largest cylinder at sea still remains 700 b.h.p., but with the particular construction in this case of opposed pistons, the number of cylinders is limited to four. The time is not far distant when Diesel engines of 400 to 500 b.h.p. per cylinder, of various types and in numbers, will be operating at sea with success. Recent advances in materials and design, but more particularly in the latter direction, have succeeded in minimising the heat flow through the material and the consequent stresses induced thereby by means of definitely controlled circulation of the cooling medium, so that with these increases in power, reliability will be unimpaired. The tendency, however, with increasing sizes will be to adopt fresh water cooling both for the pistons, cylinders and cylinder heads, so completely to obviate the chances of local heating and therefore of excessive stressing due to deposits of salt or sand. The extra complication of the coolers, circulated with salt water, for extracting the heat from the fresh water and of the extra pumps is a very minor matter compared with the security so attained.

The Diesel engine still remains a massive and somewhat complicated power plant, and no movement towards simplification has yet definitely set in. Undoubtedly, when shipowners and their superintendents have come to appreciate the principles of operation of this prime mover, a number of so-called "gadgets" at present introduced as safeguards, and in order to make assurance doubly sure, will be discarded. Only in this way does it seem possible definitely to attain greater simplicity. As regards reducing the mass of the engine, there are only two ways in which this can be achieved, either by increasing the mean effective pressure in the cylinders or the piston speed. The governing factor in the design of all internal-combustion engines is the heat flow factor. The greater the cylinder dimensions the more vital is this consideration. This factor, expressed in pounds of fuel consumed per sq. in. of combustion volume surface per unit of time, is directly dependent upon the piston speed and, for a constant factor of heat flow, the lower the piston speed the higher the mean effective pressure possible. The converse is equally true.

The tendency for some years past has been to reduce this heat flow factor with increasing size, but the gradual improvements in materials and designs which have permitted of increasing size, as already stated, now allow augmented heat flow, by increasing the mean effective pressure in the cylinders and the piston speed.

The piston speed with a single acting internal-combustion engine can well be considerably higher than with steam practice because of two considerations—firstly that the maximum pressure for which bearing surfaces are designed is only maintained for approximately 12½ per cent. in the case of four-stroke engines and 25 per cent. of the cycle for two-stroke engines, and secondly because the pressures on the bearing surfaces are not generally reversed as with double acting steam engines. The inclination, therefore, especially with four-cycle machinery is to increase piston speed. With twin screw ships of relatively high speed, revolutions higher than is usual with steam machinery can be adopted without impairing to any serious extent the overall propulsive efficiency. With single screw vessels, especially of low speed, the propeller speed must be kept low, and long stroke engines will increasingly be adopted to attain a high piston speed and good propeller efficiency.

One point that is not perhaps sufficiently emphasised, is, that with Diesel machinery, the higher the power per cylinder, the greater the weight per horse power, so that for a given power of ship, there is a definite saving in machinery weights when twin screw engines are adopted in comparison with single screw machinery. This saving in weight means a certain reduction in cost, although the lesser machinery cost is balanced by the increased cost of hull, due to the extra bossing of the stern and the two tunnels for the two lines of shafting. The chief advantage of single screw machinery lies in the reduction in personnel which is possible, as obviously an increased engine room complement is required to superintend and to manœuvre two engines. Nevertheless, for powers above 2,000 to 3,000 shaft h.p., twin screw Diesel engines will be the rule for some time to come and are to be advocated.

The saving in fuel costs with Diesel machinery must be considered in conjunction with the lubricating oil consumption, which is higher than with steam machinery. At first, this subject was not perhaps fully appreciated, but to-day it can confidently be stated that with the latest internal-combustion machinery, the problems associated with the necessary lubrication of the piston rings and the forced feed to the main bearings have been most conscientiously attacked, and the consumption of lubricating oil has been reduced to a figure of relatively small importance. 1·5 gallons of lubricating oil for all purposes per ton of fuel oil consumed should be the relation, and has been attained.

Every ship can virtually be regarded as a floating community, and the propelling machinery is not by any means the only consideration. There are the various services, bilge and ballast, heating of cabins and the machinery for handling the ship, the capstan, and the steering gear and for cargo manipulation, the winches. How shall the auxiliaries be driven? So far as steering gear is concerned the electric-hydraulic system has proved itself efficient and is finding increasing favour even on steamships. For lights, fans, electricity is also required. For the heating of a ship, steam is still the most convenient and the least costly method, although either exhaust raised steam at sea and some combination of electrically generated heat and hot water pipes will no doubt find increasing favour in the future. Therefore for the remainder of the plant, such as winches and pumps, the choice lies between steam or electric drive. Where first cost is concerned, considerable advantage lies on the side of steam, but the more elegant solution and the more economical, from the point of fuel consumption, is undoubtedly the electric drive. Electric current is generated by Diesel driven dynamos, which, except in very special cases, should not be less in number than three. For reasons of interchangeability these three should be of the same size. One should be sufficient for normal sailing at sea, two are required for manœuvring the ship or for working cargo in port, and one is always a stand-by. For ships of 3,000 tons deadweight, three sets each of 50 kw. suffice. From 6,000 tons to 10,000 tons deadweight, three sets of 80 kw. to 100 kw. are generally required. If special provision has to be made, for instance, for carrying refrigerated cargoes, the power of the sets is greatly increased, and in some cases three or four sets of 150 kw. are called for. The consumption of fuel for working cargo and pumps in port with banked fires in a steamship is of the order of 10 times the amount of fuel required by the Diesel electric system of auxiliary working on similar motor ships.

The foregoing refers particularly to 4-cycle engined ships. When 2-cycle machinery is adopted the practice of driving the scavenging pumps separately from the main engine to permit of rotary machines being used for this duty will undoubtedly gain favour, and in this case the Diesel-driven generators for supplying electric current for general duties, as well as for driving these blowers, become of very considerable size, approximately of 25 per cent. of the power of the main engine.

Such figures lead naturally to a consideration as to whether the correct angle from which to review and attack the problem is not to regard the machinery of the ship as a central electric power station delivering current to electric motors for propulsion and all the other multifarious duties. For special purpose ships, where the duties apart from propulsion require a substantial measure of the total power as, for instance, dredgers, ferry boats, cable ships, &c., the Diesel-electric system is being adopted and merits the closest attention. It is favoured in America and has been regarded also, by virtue of the great sub-division possible, as a means of adopting the Diesel principle to ships of the highest power. It is heavy, the first cost is high, and electric machinery suitable for marine work requires a certain amount of development before it will prove quite as reliable as the remainder of the installation.

The motor ship has arrived to-day at the position where the shipowner has few remaining doubts as to the capacity of the oil engine. The three factors of first cost, personnel and upkeep are still regarded, in some quarters, as deterrents. The first cost for similar sized steamers and motor ships is much in favour of the former. This is the general comparison made, although it is false. A smaller motor ship will suffice because of the saving of space due to the type of machinery, principally in bunkers, in increased radius of action per ton of fuel (although a motor ship must generally carry more fuel than a coal-fired steam ship to get full advantage of favourable fuel markets) and decreased personnel.

In inviting tenders shipowners would be well advised in order that they may accurately assess the position of the motor ship to state simply the duty of the ship and the sea speed required, leaving the contracting naval architect and marine engineer to decide the best combinations of features to meet the requirements at the minimum first cost. Such are the advantages of the motor ship, especially on certain and many important trade routes that the extra first cost is quickly written off.

The subjects of personnel and upkeep are interdependant. There is available an increasing number of engineers conversant with the first principles of internal combustion and most engine builders are only too anxious that their engineers who have worked on the construction of the machinery shall follow it to sea and form the nucleus of the engine room complement. Under such conditions the fears of excessive upkeep expenses are not well founded.

When next marine construction is energetically pursued, as undoubtedly it must be, if we are to maintain our natural and supreme position as a sea-going and trading nation, the motor ship will be in the forefront. To-day at sea the tonnage of motor ships is 6·5 times what it amounted to in 1914, and of the present total, more than one-half, or 848,000 tons, represents 149 vessels of over 3,000 tons. Of ships under construction at the present time those to be engined with internal combustion machinery form such a proportion as to make the future for this new type appear extremely bright.

ELECTRICAL IGNITION APPARATUS FOR INTERNAL-COMBUSTION ENGINES.*

By E. O. TURNER, D.Sc., A.M.I.E.E.

I. GENERAL.

Until about 10 years ago very little attention was paid in this country to the theory, design, or manufacture of ignition apparatus. Since then these subjects have increasingly occupied the attention of both engineers and physicists. Several reasons may be indicated to account for this growing interest. First of all, a great stimulus was given at the beginning of the war, when it became essential to manufacture magnetos in the allied countries; hitherto this branch of the electrical industry had been practically a German monopoly. Another reason is that the almost universal adoption on motor cars of some form of dynamo lighting and battery charging system has revived the use of the induction coil as an alternative to the magneto. A third reason may be pointed to in the recent introduction for permanent magnets of a cobalt steel alloy from which an energy per unit magnet volume of from three to four times as much as the best hitherto obtainable, may be developed; the full effect, indeed, of this remarkable discovery may not be felt for some years to come.

In previous papers which have been written on this subject attention has been directed chiefly to the magneto†; in the present paper the induction coil is examined first, and the magneto is then considered as a special type of induction coil.

Requirements to be Fulfilled by Ignition Apparatus.—Sparks have to be produced at the plug electrodes in the engine cylinder towards the end of the compression stroke. Leaving out of account the question of timing, and regarding a magneto or an induction coil simply as a form of high voltage generator, it is necessary to state as precisely as possible in what way its performance is to be judged and exactly how its output is to be measured. During the early part of the war many measurements of spark energy, voltage, and current were made, the assumption being that the values thus obtained represented figures of merit for each generator. Later investigations, however, have shown that this is not so; enormous differences in spark energy, as between widely different types and sizes of generators, have been found to cause no observable difference in the energy developed from the explosion, and the view most generally held at present by those‡ who have studied this subject may be stated as follows: If a spark actually occurs at the plug, ignition will follow, provided that an explosive mixture is present in the cylinder; however much the spark energy be varied no variation in the power developed will follow; if a spark takes place and no explosion follows no increase in the energy of the spark will cause an explosion. It is still held by some that the earlier view is correct and experimental evidence is pointed to of increased spark energy being accompanied by increased engine power. To this the reply is that under certain adverse conditions sparking may not be absolutely regular, and as such missing is, at high speed, difficult to detect, it is not unnatural to ascribe the increased power to increased energy per explosion,

* Paper read before Section G of the British Association meeting at Hull, September 13, 1922.

† See Watson: "Magnetos for Ignition Purposes in Internal-Combustion Engines," *Journal*, I.E.E., vol. lix, p. 445, which also contains an excellent bibliography.

‡ See Morgan: "Principles of Electric Spark Ignition in Internal-Combustion Engines," p. 15.

when rightly the increase ought instead to be attributed to an increased number of explosions of the same energy.

Assuming then that it is necessary merely to cause a spark without any regard as to its character, the requirements to be fulfilled by an ignition generator may be stated thus :—

(1) The spark must take place at a cylinder compression varying, according to the type of engine, and the conditions of working, between 30 lb. and 160 lb. per square inch. The voltage required to break down the gas between these limits of pressure depends on several factors, but may be taken roughly as from 5,000 volts to 25,000 volts.

(2) Sparking must be absolutely regular between whatever limits of low and high speed are required by the engine to be fired.

(3) The functioning of the generator should be as far as possible unaffected by such variations as may occur in the external circuit to which it is connected.

As regards the first of these requirements the highest pressures are required on large stationary engines; automobile engines do not as a rule operate with pressures much exceeding 100 lb. per square inch. So far as automobile engines are concerned, it has also to be taken into account that the spark takes place at high speed in a much lower compression than at low speed; one reason for this is that, in order to develop the maximum power, the spark is (at high speed) timed to take place considerably before the end of the compression stroke, and consequently before the maximum compression is reached; another reason is that at high speed there is a certain amount of unavoidable throttling in the induction system, which will result in a lower pressure than at slow speed throughout the whole of the compression stroke. In the following table particulars of a number of automobile engines of different characteristics are collected; from this it is seen that the compression at the moment of explosion may be at high speed actually less than half the maximum, or slow speed, compression.

Cylinder Compressions at Maximum Engine Speed.

Maximum Engine Speed.	Maximum Angle of Advance.	Compression Lb. per Sq. In.		Ratio of Actual to Maximum Compression.
		Maximum Possible.	Actual (at Stated Angle).	
2,500	45	100	45	0·45
2,800	45	100	58	0·58
3,000	45	100	53	0·53
3,700	50	130	63	0·48

The limits of speed between which the generator must function—the second requirement referred to above—vary of course according to the type of engine; the upper limit depends on the maximum engine speed and the number of cylinders. It would be better if there were no lower limit, but as a magneto must be turned at a certain speed in order to begin sparking, care must be taken that this speed is slightly less than that at which the engine can be turned by whatever means for starting it is adopted.

The third requirement refers to variations in the external circuit. The two factors which affect the sparking most are the presence of capacity in series with the plug electrodes, and the joint resistance of the leakage paths in parallel with them. The former is of importance only when very long leads are run to the plugs and are surrounded by metallic sheathing; as a general rule the capacity thus introduced may safely be ignored. Leakage resistance paths, however, are liable seriously to affect the sparking, and they therefore require some consideration. If a resistance of, say, 100,000 ohms were connected in parallel with a plug, it would be found that unless the ignition generator were a particularly robust one, the spark would be quenched, the resultant load on the generator being, through this additional circuit, sufficient to reduce its terminal voltage below the value necessary to break down the gap. It is, unfortunately, impossible to prevent the formation of a number of these branch circuits; some of them, owing to the presence of moisture, consist of paths of surface leakage across the insulation, both at the generator and at the plug terminals; others are formed through the body of the plug, and their resistances vary according to the temperature of the plug, the amount of carbon which may have been deposited on it, and other factors. All these paths are in parallel with the main circuit. The third requirement—that the generator shall be as far as possible unaffected by variations in the external circuit—may thus be given the following definite form: if R is a resistance in parallel with the spark gap and is gradually reduced to a value R_1 at which the sparking begins to be irregular, then $1/R_1$ is a measure of the ability of the generator to spark under adverse circumstances. If R_1 is expressed in ohms, $10^6/R_1$ has been termed the "utility" of the generator at the voltage or with the spark gap conditions at which the test was made.*

So far as automobile engines are concerned, the effect of varying compression with speed may be taken into account by requiring that the utility shall be considerably greater at the minimum than at the maximum speed. I find, for instance, that an ignition generator designed to have a maximum (slow speed) utility of about two to three times the minimum value (at maximum speed) has approximately a uniform breakdown factor at all speeds. A method of comparing the performance of generators of different design may now be considered.

*See Bairsto: "The Effect of Shunted Resistance, or Plug Leakage on the Sparking Performance of an Electrical System," *Journal* I.E.E., 1920, vol. lviii, page 507.

Figures of Merit for Comparing Ignition Generators.

1. *Induction Coils.*—It may be assumed that coils are compared which operate at the same maximum speed and that they have (as just described) a uniform breakdown factor. Their performance can then be judged by considering the utility (U), the input to the primary circuits ($E_1 I_1$), and the lowest supply voltage at which the coils will function (e_1). As regards the last named, it is very desirable that the coil should operate at a supply voltage well below the normal, and as it is possible—by reducing the number of secondary turns, for example—to increase the utility at the expense of the low voltage performance, the latter should be included in a proposed figure of merit. The expression

$$\frac{U}{E_1 I_1} \times \frac{E_1}{e_1} = \frac{U}{e_1 I_1}$$

representing the utility generated per watt supplied, modified according to the low voltage performance, serves as a useful index figure. It will be seen, below, to have some resemblance to the output coefficient—as used in connection with other classes of electrical machinery.

2. *Magnetos.*—The performance of a magneto is determined chiefly by the available energy of its magnet. In Fig. 1 a portion of a magnetisation curve STU is shown; if a magnet of cross sectional area A and length L is chosen, then the following relationships exist, Φ being the total magnet flux and In the magneto motive force available in the external circuit :

$$A = \Phi/TV \text{ and } L = In/OV$$

The magnet volume V = AL may thus be represented by the expression $\Phi In/(OV.\ TV)$, which will be a minimum for any given values of Φ and In when the product OV. TV is a maximum. There is obviously a maximum product at some value of H intermediate between zero and the coercive force, and a well designed magneto will be arranged to operate so that its magnet works in the neighbourhood of this maximum. Thus, if $(BH)_m$ represents the maximum energy per unit, volume $V(BH)_m$ is the total available magnet energy. A figure of merit may now be written in the form—

$$M = U/\{N.V(BH)_m\}$$

N, the least sparking speed, is introduced for a similar reason to the least sparking voltage of an ignition coil, since U and N can be varied almost in direct proportion to each other. The resemblance between the two expressions just suggested and the output coefficient for electrical machinery, is seen from the following table :—

Type of Unit.	Figure of Merit.
Induction coil ..	Utility. / Least sparking voltage × Supply current.
Magneto	Utility. / Least sparking speed × Magnet energy.
Dynamo or motor ..	Output. / Least speed of operation × Rotor volume.

Contact Breakers.—Certain difficulties in providing current interrupters to suit all conditions that arise are common to both induction coils and magnetos, and may be referred to here. As regards contact materials, a platinum-iridium alloy containing 25 per cent. of the latter metal has so far proved for many purposes the most suitable. It has, however, two drawbacks: it is expensive, and when interrupting unidirectional current a deposit of positive contact material is made at an apparently uniform rate on the negative contact face. As an example of this, the figures obtained in a certain test may be quoted. With contacts 3·75 mms. in diameter interrupting 2 amperes at 12 volts 3,600 times per minute, after operating for 600 hours the positive contact was reduced in thickness by 0·46 mm., whilst the negative had increased by 0·34 mm. The first drawback, that of expense, may be partially remedied by reducing the percentage of iridium, but this introduces the serious disadvantage that the material is softer and suffers much more readily from the mechanical hammering to which it is subjected. As practically only point contact is established it would seem to be the best policy to use as hard a material as possible. Tungsten, as a contact material, is free from the objections so far referred to; it is comparatively cheap, there is no transference of metal from contact to contact, and it is very hard. It has one great drawback, however. Under certain circumstances the resistance between closed contacts appears after working for some time to rise to an unduly high value; this is a serious matter, and particularly so with magnetos, in which any increase of resistance is at once reflected in a worse slow speed performance. It is difficult to speak with any certainty as to the reason for this increased contact resistance, as the change in the condition of the contact faces to which the difference is to be attributed is very slight, and further information on this subject would be of great service to both makers and users of ignition apparatus.

The form of contact breaker usually adopted is such that the contacts are opened by means of a cam operating a lever against the pressure of a spring, the latter being relied upon to close the contacts. Extreme care is required both in the design and manufacture of the contact breaker to ensure satisfactory operation at the extremely high speeds which are now required with multicylinder automobile engines. A six-cylinder engine, for example, which is to operate at 4,500 r.p.m., requires 13,500 makes and breaks per minute; assuming that the time of make occupies two-thirds of the total period, the time of contact is 3 milliseconds. Some engine makers call for considerable accuracy in the intervals between successive explosions—for example, it may be stipulated that the difference between the actual and theoretical successive firing angles shall not exceed 1 deg. —measured on the crank shaft. To meet this requirement it is necessary that the opening shall take place comparatively abruptly, but unfortunately this tends to produce flinging at very high speeds, that is to say, the lever does not strictly follow the cam, but lags behind, with the result that the break period is prolonged and the make period correspondingly shortened. So far as the magneto is concerned, a slight amount of flinging at high speed is of no great importance as the angle at which the break takes place will not be affected, and there is a large surplus energy at high speed, a slight reduction of which, owing to a reduced time of contact, will still leave a utility considerably in excess of the low speed value. With coil ignition, however, it is imperative that there shall be no flinging at all. A coil designed to operate with the least possible primary current will, at maximum speed, break a current much below the maximum. Any reduction of time will mean a still further reduction in current which must, as far as possible, be avoided. I have found that a suitable test for flinging is to measure, with a moving coil ammeter, the variation with speed of the apparent current in a strictly non-inductive circuit interrupted by the contact breaker under examination. As long as there is no flinging the ammeter reading will be constant at all speeds, the ratio between this apparent current and the actual current interrupted being dependent solely on the ratio of make to break intervals. If any flinging takes place the break period will be prolonged and the ammeter reading will fall. This test is a useful preliminary to any high speed tests on ignition coils, as it enables the performance of the coil to be observed without being obscured by independent variations taking place elsewhere.

2. Ignition by Induction Coil.

The Magnetic Circuit.—Most induction coils are built with only a core of magnetic material, the circuit being completed through an air path. Unless the outer diameter of the coil is small in comparison with the core length the linkage of flux with the outer layers of the winding will be far from complete. The object of the designer being the transference of as much energy as possible from the primary to the secondary circuit rather than the establishment of a high peak voltage,* the coupling between the windings should be as close as possible, and, accordingly, this partial linkage is to be avoided as far as possible. In order to overcome this drawback laminated steel cheeks of diameter preferably exceeding that of the coil, fitted so as closely to embrace the core, are sometimes added. For a circuit of this form I found that the value of mutual inductance (M) was about 85 per cent. of the inductance of the primary winding (L_1)—equal primary and secondary turns being assumed. With a construction employing only a core of iron, I found it difficult, observing the limitations imposed by mechanical considerations, to increase M much above 0·70 L_1. It may be noted that, when such end cheeks are fitted, the field due to the primary is partially screened and does not stray over so large a space; a coil of this construction is thus less likely to be affected by being mounted in the neighbourhood of a large mass of solid metal.

Primary and Secondary Windings.—Considerable care is required in deciding the number of primary and secondary turns if the maximum utility is to be obtained for a given input. If high speed conditions are first studied it will be found that if very few primary turns are employed M.M.F. and flux will be correspondingly low; if too many are chosen the current will only have risen to a small proportion of its final value before it is cut off, and the M.M.F. will still be low; there is thus a definite number of turns which will establish the greatest core flux. Since at high speed, that is with primary current considerably below the maximum, the flux density in the iron will be low, L_1 may be expressed in the form $a\ n_1^2$, where a is a constant depending solely on the shape of the magnetic circuit. By this means, and the equation for the rise of current in an inductive circuit, the best value for n_1 may be found.

At speeds below the maximum, if the iron ampere turns are appreciable, L_1 is not a constant for any given number of turns, as it varies with the instantaneous value of the current, and it must therefore be expressed in terms of the magnetisation curve of the coil. If the equation for the rise of current is transformed into the form—

$$t = \frac{\Phi_1 n_1}{10^8 R_1 i_1} \log \frac{I_1}{I_1 - i_1}$$

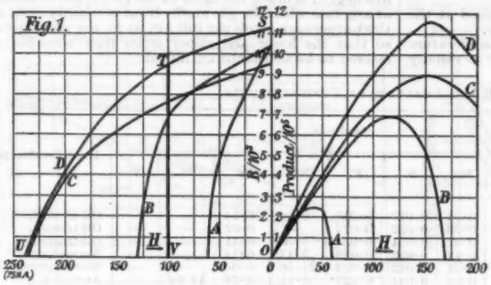
by tabulating assumed values of i_1 the corresponding value of the primary M.M.F. $n_1 i_1$ and the flux Φ may be found and values of t worked out and plotted against i_1. This procedure is necessary since the magnetisation curve of the coil cannot readily be expressed in the form of an equation.

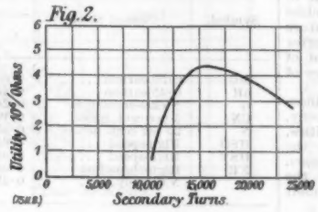
The number of secondary turns should be as small as is

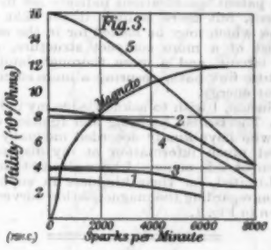
* See Taylor-Jones: "The Theory of the Induction Coil," a most important work on this subject, which also includes a chapter on the magneto.

consistent with satisfactory performance at reduced voltage. When operating on a circuit of low insulation resistance the leakage current may be comparatively large—for instance, a utility of 10 at 10,000 volts means a secondary current of 0·10 amperes in addition to the spark current. If more turns are employed than are necessary to establish the breakdown voltage, the secondary current, flowing in these unnecessary turns, will represent a considerable voltage consumption; this may be an important factor in accounting for the reduced utility which is associated with too many secondary turns.

Fig. 2 shows the result of tests on coils having the same number of primary turns but with varying secondary turns; it is seen that there is a well-defined maximum







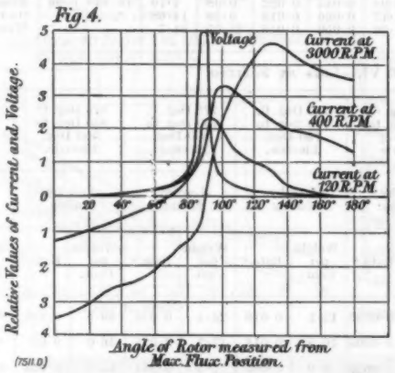
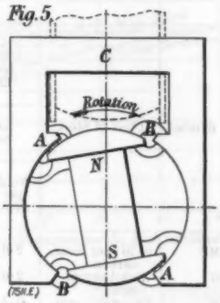
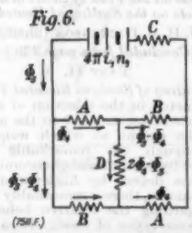


Fig.4.
Voltage
Current at 3000 R.P.M.
Current at 400 R.P.M.
Current at 120 R.P.M.
20° 40° 60° 80° 100° 120° 140° 160° 180°
Relative Values of Current and Voltage.
Angle of Rotor measured from Max. Fluxc. Position.
(7SII.D)





3. MAGNETO IGNITION.

During the first part of the cycle of spark production the secondary winding may be practically ignored and the magneto may be considered as an alternator—of which the primary circuit constitutes its armature winding—working on short circuit. In Fig. 4 a number of curves are shown, which have been obtained by measuring the instantaneous primary currents and voltages of a magneto at different speeds and rotor angles, the latter being measured from the position of maximum flux linkage of magnet with armature. At very low speeds the current is practically proportional to the voltage; since the reactance is proportional to the speed the resistance is the chief factor connecting the two. Thus the current curve at low speed resembles the open circuit voltage curve. As the speed is increased the reactance of the armature becomes increasingly important so that the peak of the curve not only rises but moves more and more to the right, the current lagging behind the voltage by a greater angle as, with higher speed, the reactcontacts open Φ_1 immediately collapses, as in an induction coil, cutting the secondary turns and producing the spark. Thereafter open circuit conditions are established until the contacts close, when the cycle begins again. From Fig. 6 the following equations representing the conditions immediately before the break, may be formed:

$$4\pi i_1 n_1 = C\Phi_0 + A\Phi_1 + B(\Phi_1 - \Phi_2)$$
$$\text{and } \Phi_2(A + 2D + B) = \Phi_1(B + D)$$

From these Φ_0, which may be termed the "spark flux," can be expressed in terms of the armature M.M.F. and the joint permeance of the branch circuits, thus:

$$\Phi_0 = 4\pi i_1 n_1 \left\{ \frac{A + B + 2D}{2AB + D(A + B) + C(A + B + 2D)} \right\}$$

As soon as Φ_0 is found the problem of the magneto becomes a common one with that of the induction coil; the armature current and the core flux in both are built up slowly and collapse quickly, and are the chief factors in determining the utility of the spark. The joint permeance can be worked out semi-graphically or can be measured experimentally. it is greater at 100 deg., the angle corresponding to the furthest advanced timing, and falls steadily between this angle and 130 deg. As is evident from Fig. 4, the predetermination of the current broken at various speeds is much more difficult in a magneto than in an induction coil, the variation of induced voltage with speed, and the variation of impedance, due to the different positions of the rotor and to the varying phase-angles between current and voltage as the ratio of resistance to reactance alters, introduce complications which were absent in the former problem; an examination, however, of current and permeance curves which have been determined by experiment will generally afford useful information from which the best solution of any particular problem may be found. The utility curves of most magnetos are very similar in shape; a typical example is shown in Fig. 3. The greatest drawback of the magneto is the inherent weakness of the spark at slow speed, when the utility should be greatest. The best that can be done is to increase the product $i_1 n_1$ at low speed by employing as large a total cross-sectional area of primary winding as is compatible with leaving room for the secondary winding. This has the effect of reducing the resistance of any given winding to the lowest possible value. The actual number of turns employed will, however, have no effect on the product provided the total area of the wires is the same. For the same reason as in the induction coil the number of secondary turns should be as few as is compatible with satisfactory performance at slow speed.

The Use of Cobalt Steel Magnets.—There are a number of drawbacks associated with magnetos having rotating armatures—the most familiar type obtainable at present—from which hitherto there has apparently been no means of escaping. The lamination of the armature core, for example, is necessarily very imperfect. The actual laminations employed form only about a half or less of the total core length, and they are not only supported by large solid-steel cheeks carrying flux but the effective lamination is also reduced by a number of rivets right through the structure, while the necessity for a considerable portion of the flux to cross the remaining laminations transversely is a still further source of loss. Other drawbacks involved, such as rotating windings, rotating contact breakers, and the large number of carefully insulated parts which form a kind of high tension transmission line from armature to plug, reflect more on the reliability of the magneto than on its utility or its figure of merit. The recent introduction however of cobalt steel for magnets offers the means of overcoming a number of the difficulties alluded to, and it is likely that in a short while the use of tungsten magnet steel, at all events so far as magnetos are concerned, will be entirely superseded. In Fig. 1 are shown

ANALYSIS OF COIL PERFORMANCES.

Description of Magnetic Circuit.	Watts $E_1 I_1$	Primary ampere-turns $I_1 n_1$	Core Flux Φ	No. of Secondary turns T_2	Utility at		Ratio of lowest to normal Voltage.	Figure of Merit (6) / (2) × (8)
					Low Speed.	7,000 sparks per minute.		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Core and flanges .. (1)	21·6	630	11,000	24,000	3·0	1·0	0·48	0·29
Core and flanges .. (2)	24·0	730	12,800	15,000	7·7	4·9	0·42	0·77
Core only .. .. (3)	24·0	1,460	10,000	45,000	3·7	2·7	0·19	0·81
Core and flanges .. (4 and 5)	21·0 30·0	810 1,150	12,000 16,800	11,000 —	8·5 15·9	4·3 6·0	0·50 0·5	0·81 1·06

utility at about 16,000 turns. It will be noted that no attempt has been made to estimate the utility directly. It is my experience that the impossibility of determining the rate of decay of the flux which depends on the effective lamination of the iron and on other factors, makes this impracticable; where the type of the magnetic circuit is fixed, however, the core flux, as suggested above, bears a close relationship to the measured utility.

In the accompanying table and in Fig. 3 particulars are given of the windings and a number of representative coils.

Coils numbered 1 and 2 have exactly similar magnetic circuits. The improved performance of the latter is due partly to the increased primary M.M.F., but chiefly to the fact that the number of secondary turns on the former coil are many more than are required to give the best performance. In coil 3 the increased primary M.M.F. establishes a lower flux on account of the longer proportion of the flux path which is in the air; the very large number of secondary turns ensures a spark being produced at a very low voltage, but only at the expense of the utility, which is correspondingly low. Coils 4 and 5 have the same winding and differ only in that the latter was tested at a higher voltage. They differ from 1 and 2 chiefly in that special precautions were taken in coils 4 and 5 to ensure complete lamination of the iron parts. The effect of this, together with increasing the primary ampere turns to the limit beyond which the high speed utility would suffer, is to enable a high figure of merit to be obtained with still fewer secondary turns.

ance predominates over the resistance. The contact breaker is arranged to break the circuit at any angle between about 100 deg. and 130 deg. according to the timing required by the engine. The current broken will depend, therefore, partly on the timing and partly on the speed of the rotor.

The second part of the cycle may now be considered. In Fig. 5 the principal flux paths and reluctances are indicated diagrammatically; a rotating magnet and a fixed armature are shown, but the following applies equally to the opposite form of construction. The reluctance of the air gaps at diagonal tips may be assumed to be equal; each trailing tip is marked A, and each leading tip B. In addition there are the magnet leakage flux air paths, chiefly in a plane perpendicular to that of the paper, the reluctance of which may be called D, and the iron path of the armature shoe extensions and the armature core, the reluctance of which may be called C. The change in the distribution of flux as the contact breaker opens can best be studied by applying Ohm's law in a magnetic circuit. The magnet, which is a substantially constant flux generator, can take no part in the flux change, and it may accordingly be regarded that the armature M.M.F. $4\pi i_1 n_1$ establishes a core flux Φ_1, which is dispersed in a network of branch circuits, as shown diagrammatically in Fig. 6, each flux being regarded as superimposed on the fluxes already existing and due to the magnet M.M.F.; the circuits shown in Fig. 6 are intended to correspond exactly to the actual flux paths shown in Fig. 5. As soon as the

portions of the hysteresis loops and also the products of B and H plotted as a function of H for different magnet steels. From this it will be noted that the maximum B H product obtainable from a good tungsten steel magnet, curve A, is about 260,000. The earliest samples of cobalt steel gave a curve similar to B, having a maximum product of about 700,000. To-day curve C, with a product of 900,000, is an average sample, and results as shown in curve D are by no means uncommon. It will be noted that the flux density at which the maximum product occurs is approximately the same both for tungsten and for cobalt steel; thus, to establish a given flux, the same area of cross section is required for both, but whereas the value of H available for the external circuit with the former material is about 35, for the latter it is about 150, so that the cobalt steel magnet need be only about one-quarter of the length of the tungsten steel magnet it replaces. Merely shortening the magnet is of itself no great improvement and would not appreciably affect the utility or the figure of merit of the magneto. The substitution of a much shorter magnet, however, makes other forms of construction possible which do not possess the drawbacks referred to in the rotating armature machine. It is as yet too soon to discuss the various arrangements which recently published patent specifications indicate are in course of development, but there is little doubt that the chief advantages which may be looked for in the near future will consist of a more compact structure, a shorter magnetic circuit, and a more thorough lamination of the armature flux path, ensuring a more efficient use of the magnet energy.

In conclusion, I wish to acknowledge my indebtedness to Messrs. The British Lighting and Ignition Company, Limited, who have kindly accorded me many facilities, and placed much information at my disposal, in the preparation of this paper. I have also to thank Messrs. Vickers, Limited, for their kindness in supplying the information regarding the magnetisation curves of cobalt steel shown in Fig. 1.

THE FLOW OF STEELS AT A RED HEAT.

*Some Experiments on the Flow of Steels at a Low Red Heat, with a Note on the Scaling of Heated Steels.**

By J. H. S. DICKENSON (Sheffield).

(*Concluded from page* 329.)

PART II.

Note on the Scaling of Steels at Elevated Temperatures.—An important factor in the selection of steel for use in many heated structures, exposed to the air or to oxidising gases, is the extent to which weight is lost by "scaling." Although the remarkable resistance to oxidation offered by certain nickel-chromium alloys, and in somewhat less degree by high-chromium steels, is fairly generally known, there is remarkably little published information regarding the relative behaviour, in this respect, of various types of steel. Because such comparisons as have been published are usually of a somewhat arbitrary nature, it may be of interest to give the results of an investigation to determine, for a selection of typical steels, the relationship between the rate of scaling, stated as loss of weight in grammes per square inch of superficial area per hour, and the temperature.

Selection of Typical Steels.—Eight typical steels, and one sample of a nickel-chromium alloy, having analyses as in Table V, were selected for examination. It will be observed that several of these steels were used in the experiments previously described. The alloy was rolled to ½ in. diameter; all the others to ¾ in. diameter, round.

Details of Experiment.—From each sample of steel nine cylinders, each 0·500 in. diameter by 2·00 in. long, were machined, polished with emery, and weighed. A complete collection of test cylinders, one of each steel, has been heated for a total time of 100 hours, within each of the following temperature ranges:—

In an Electric (Nichrome Wound) Muffle Furnace. Internal Dimensions, 8¼ in. by 6 in. by 3½ in.	In a Gas-Heated Muffle Furnace. Internal Dimensions, 6 in. by 4 in. by 3 in.
Collection A 550 deg. C. to 600 deg. C.	Collection F 850 deg. C. to 900 deg. C.
Collection B 650 deg. C. to 700 deg. C.	Collection G 920 deg. C. to 970 deg. C.
Collection C 700 deg. C. to 750 deg. C.	Collection H 1,000 deg. C. to 1,050 deg. C.
Collection D 750 deg. C. to 800 deg. C.	Collection I 1,075 deg. C. to 1,125 deg. C.
Collection E 850 deg. C. to 900 deg. C.	

In order to maintain, throughout the 100 hours, a practically uniform rate of oxidation, which slows down as adhering scale increases in thickness, the heating was carried out in 18 periods of approximately equal length, of about 5½ hours each, the specimens being scraped free of scale, and weighed, after each cooling. This had the further advantage of permitting the nine specimens of each collection, which were placed about ¼ in. apart, on end, in a ring round a centrally placed thermocouple, to be moved one place, in a clockwise direction, after each removal. Each test cylinder thus made two complete circuits during the 100 hours, so that any possible inequalities which might have arisen from slight temperature variations, or air currents from a small opening left in the muffle front, were eliminated.

* Abstract of a paper read at the meeting of the Iron and Steel Institute at York, on Wednesday, September 6, 1922.

Although it was found impracticable to maintain the temperature, which was recorded by a Cambridge thread recorder, perfectly constant in the middle of the temperature range, it may be taken that the limits (50 deg. C.) were never exceeded, and that the actual mean temperature of the trials may be fairly stated as 575 deg., 725 deg., and so on.

Statement of the Results Obtained.—It may be stated at the outset that the two carbon steels showed almost exactly the same scaling rates throughout, as also did the two high-speed steels. It is therefore proposed to simplify the diagrams by giving, of these, only the results obtained from the 0·30 per cent. carbon steel, and the lower tungsten high-speed steel (H8O). The 5 per cent. nickel steel and the nickel-chromium steel (G) also behaved so very much alike that only the results from the former are given.

It is proposed to report the results obtained at the lower and upper ranges somewhat differently.

None of the specimens heated in the four temperature ranges up to 750 deg. to 800 deg. C. scaled so rapidly that the weight after successive heatings, plotted against the time, showed any serious departure from a straight line. In these cases, therefore, the rate of loss by scaling, expressed as grammes per square inch per hour, may be readily calculated, with sufficient accuracy, from the total loss of weight in 100 hours and the original surface area, the results being set out in Table VI, along with the corresponding percentage loss of weight in 100 hours.

This table also gives the figures for the two collections heated, one in the gas and the other in the electric furnace, in the 850 deg. to 900 deg. C. range, but at this temperature certain specimens did suffer appreciable reduction of surface area, and the rate of loss was calculated from the weight shown at 50 hours on the smoothed weight-time curve, the first half of this curve being sufficiently nearly straight in all cases.

As the two series at the range 850 deg. to 900 deg. C. were carried out with the object of linking together the lower temperature series, heated in an electric furnace, where the specimens were surrounded by air, and the higher ranges heated in the less pure atmosphere of a gas muffle, it is desirable to consider the results somewhat closely.

It will be noted that the carbon steel, nickel-chromium steel, and high-chromium steel specimens of the two series give remarkably similar results,* but that the 25 per cent. nickel steel and high-speed steel show marked differences. Of these the former discrepancy is readily explained by a peculiarity in the scaling of high-nickel steel, which will receive some attention later; but the author is still unable to explain why the high-speed steel specimen, heated at 875 deg. C. in the gas furnace, should have lost weight at about the same rate as the corresponding electrically-heated specimen during the first 50 hours, and afterwards have scaled so much more rapidly. However, after careful examination of the plotted weight-time curves the scaling rates were determined as shown in Table VI, and are certainly not far from the truth.

It appears that, on the whole, the rate of scaling at 875 deg. C. is much the same in the two types of furnace, at any rate when the gas muffle front is slightly open and the burners are receiving full air, as in the present case, so that the lower and upper series may thus be considered to be satisfactorily linked.

TABLE V.—ANALYSES OF TYPICAL STEELS.

Symbol.	Class of Steel.	Analyses. C.	Si.	Mn.	S.	P.	Ni.	Cr.	W.	V.	Heat-Treatment.
MC	0·30 carbon	0·30	0·12	0·54	0·027	0·038	0·51	0·14	—	—	Oil-treated.
6H	0·45 carbon	0·45	0·37	0·79	0·022	0·024	—	0·02	—	—	Oil-treated.
G	Nickel-chromium ..	0·28	0·20	0·31	0·034	0·033	3·70	0·71	—	—	Oil-treated.
CN	5 per cent. nickel ..	0·10	0·08	0·12	0·032	0·036	5·43	0·14	—	—	Normalised.
N	25 per cent. nickel ..	0·27	0·16	1·21	0·022	0·024	24·36	0·06	—	—	Water-quenched.
H8O	High-speed	0·65	0·30	0·22	0·041	0·027	0·12	3·73	13·68	—	Annealed.
H8V	High-speed	0·85	0·40	0·23	0·044	0·022	0·08	4·19	18·36	0·96	Annealed.
NR	High-chromium ..	0·26	0·59	0·17	0·066	0·016	0·39	14·68	—	—	Oil-treated.
V	N.C. alloy	0·29	0·87	1·80	0·050	0·018	65·05	11·7	—	—	Water-quenched.

TABLE VI.—LOSS BY SCALING.

Symbol.	Class of Steel.	575 Deg. C. 550 Deg. to 600 Deg. Electric. Loss by Scaling. Weight per Cent.	Rate.*	675 Deg. C. 650 Deg. to 700 Deg. Electric. Loss by Scaling. Weight per Cent.	Rate.*	725 Deg. C. 700 Deg. to 750 Deg. Electric. Loss by Scaling. Weight per Cent.	Rate.*	775 Deg. C. 750 Deg. to 800 Deg. Electric. Loss by Scaling. Weight per Cent.	Rate.*	875 Deg. C. 850 Deg. to 900 Deg. Electric. Loss by Scaling. Weight per Cent.	Rate.*	875 Deg. C. 850 Deg. to 900 Deg. Gas. Loss by Scaling. Weight per Cent.	Rate.*
MC	0·30 per cent. carbon	2·0	0·0027	6·3	0·0080	13·1	0·018	25·4	0·036	59·5	0·100	62·9	0·094
G	Nickel-chromium	2·0	0·0027	7·4	0·0095	10·8	0·014	17·7	0·025	46·0	0·08	48·2	0·070
N	25 per cent. nickel	0·4	0·0005	1·6	0·0022	3·9	0·005	7·5	0·011	24·1	0·054	14·4	0·023
H8O	High-speed ..	0·7	0·0011	2·7	0·0038	4·3	0·006	6·9	0·010	30·6	0·054	42·3	0·06
NR	High chromium	nil	nil	0·4	0·0005	0·8	0·001	1·2	0·002	5·0	0·007	5·9	0·008
VIKRO	N.C. alloy ..	nil	nil	nil	nil	0·1	—	0·2	—	1·1	0·0017	0·8	0·0011

* Rate means loss of weight in grammes per square inch per hour.

TABLE VII.—SCALING RATES.

Symbol.	Class of Steel.	Scaling Rate in Grammes per Square Inch per Hour at Mean Temperature Indicated. Electric Furnace. 575 Deg. C.	675 Deg. C.	725 Deg. C.	775 Deg. C.	875 Deg. C.	Gas Furnace. 875 Deg. C.	945 Deg. C.	1,025 Deg. C.	1,100 Deg. C.
MC	0·30 per cent. carbon	0·0027	0·0080	0·018	0·036	0·100	0·094	0·160	0·37	0·55
G	Nickel-chromium	0·0027	0·0095	0·014	0·025	0·080	0·070	0·130	0·32	0·60
N	25 per cent. nickel	0·0005	0·0022	0·005	0·011	0·054	0·023	0·100	0·21	0·41
H8O	High-speed	0·0011	0·0038	0·006	0·010	0·054	0·060	0·095	0·25	0·47
NR	High-chromium	nil	0·0005	0·001	0·002	0·007	0·008	0·017	0·14(?)	0·27
VIKRO	N.C. alloy	nil	nil	—	—	0·0017	0·0011	0·0014	0·002	0·008

A specimen of NR, specially heated at a mean temperature of 980 deg. C., gave a scaling rate of 0·028.

The great rapidity with which many of the specimens scale away at 920 deg. to 970 deg. C. and upwards, and the correspondingly rapid diminution of the surface area, makes it necessary to calculate the loss of weight per square inch per hour on quite short time intervals, as will be obvious from Figs. 15, 16 and 17, on which all the successive weighings of each specimen, of the 945 deg., 1,025 deg. and 1,100 deg. C. ranges, respectively, are plotted against the time of heating. Most of the plotted lines show very considerable curvature, and not a little irregularity, distinct waves, due to the rotation of the specimen round the muffle floor, being observable in some cases, but the true form of the curve is quite obvious in all cases.

These diagrams bring out, among other things, the remarkable resistance to oxidation of the nickel-chromium alloy, and a curious stepping in the 25 per cent. nickel line, but the principal object of this work, an exact comparison of the different steels, is better afforded by the scaling rates derived from these diagrams. These

* The apparent slight discrepancy between scaling rates and percentage loss of weight arises because the former is based on the first 50 hours, and the latter on the total time.

are set out, along with those of the lower temperature ranges, in Table VII, and are plotted in Fig. 18.

To obtain the rate of loss of weight, in grammes per square inch per hour, each plotted line in Figs. 15, 16 and 17 was carefully smoothed to give an obvious and natural curve for the total time, by means of a flexible lancewood strip.

The loss of weight on the first 10 hours of this line, this length of the curve being always nearly straight, even in the most rapidly scaled specimens, was usually taken as the basis for the calculation; but in some cases specimens were measured at various periods, so that the loss of weight for a short period immediately previous, or subsequent, to each measurement of superficial area could be taken from the smoothed curve, and a check calculation of rate made. It was found that until the specimen was reduced to very small diameter, say well under 0·10 in., when an increase occurs, the gas furnace, and indeed the point at 1,025 deg. C. looks to be out of place even as plotted in Fig. 18.

Fig. 19 suggests that the relationship between the rate of oxidation and the temperature is governed by a simple law, which is the same for all the steels examined. In actual fact, if the same data are plotted in terms of their logarithms, taking the logs. of the absolute temperatures and the logs. of the scaling rates as co-ordinates, the points still fall on to reasonably straight lines, in which case the relationship may be expressed as $R = T^n$, where R is the rate of oxidation and T is the temperature.

Micro-Examination.—A brief account may be given of the micro-examination of a complete series of specimens, heated in the electric furnace at 900 deg. C. for 24 hours, and then heavily copper-plated, to hold the scale in position before sectioning.

These showed a marked difference in the formation of the scale upon the carbon, high-speed, and high-

This scale shows separation in differently coloured layers, but there is no band containing unoxidised metal.

It remains to be added that the oxide layer on the high-chromium steel sample was barely visible between the copper and the steel, while that on the nickel-chromium alloy was so thin as to be quite unrecognisable on the section.

In concluding, the author wishes to express his gratitude to a number of his colleagues, whose friendly assistance has been of great value in carrying out this work. He would like particularly to thank Mr. J. H. Huxley, A.R.S.M., F.I.C., for the chemical analyses, and Mr. J. P. Nicholson for general assistance in the mechanical testing. He is also glad to record his indebtedness to his assistants, and in this connection more particularly to Mr. B. Ludgate, who has cheerfully sacrificed a portion of each Sunday, for more than a year, in order to make the daily measurements of

Fig. 15. DIAGRAM TO SHOW THE LOSS OF WEIGHT, BY SCALING AT 945°C.

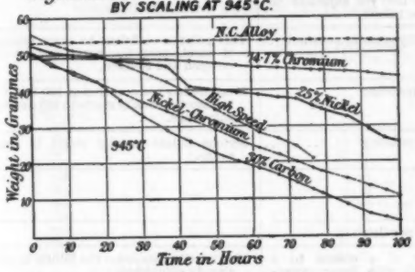


Fig. 16. DIAGRAM TO SHOW THE LOSS OF WEIGHT, BY SCALING AT 1025°C.

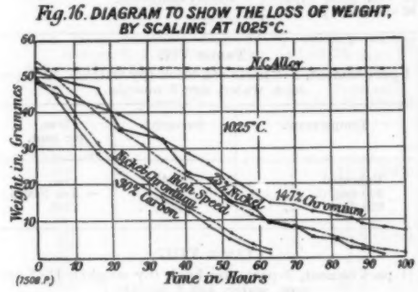


Fig. 17. DIAGRAM TO SHOW THE LOSS OF WEIGHT, BY SCALING AT 1100°C.

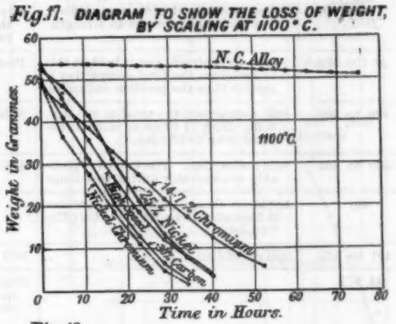
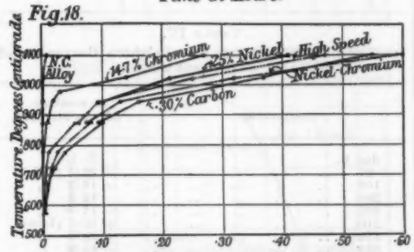
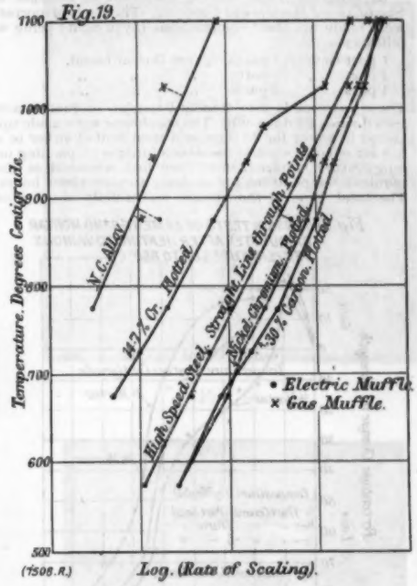


Fig. 18.



(1508.9.) Loss of Weight in Grammes per Sq. Inch per Hour.

Fig. 19.



(1508.8.)

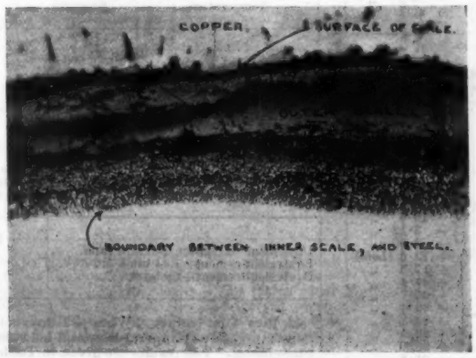


FIG. 20. DOUBLE SCALE ON SURFACE OF 25 PER CENT. NICKEL STEEL. UNETCHED. × 50.

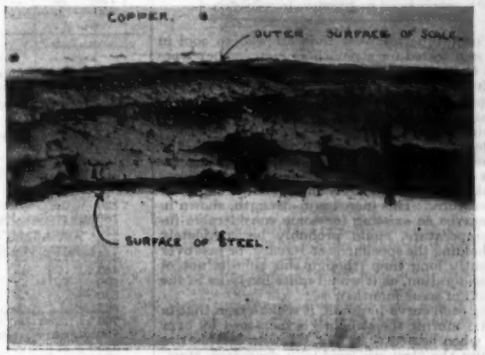


FIG. 21. SCALE ON SURFACE OF 0·30 PER CENT. CARBON STEEL. UNETCHED. × 50.

scaling rates obtained by this method were remarkably consistent.

Examination of Fig. 18 shows that the connection between the electric and gas-heated series, at 875 deg. C., fits in very well with the general shape of the curves. This diagram needs very little discussion, since it shows at a glance the temperature at which scaling becomes appreciable on each of the six steels examined. If, for example, a scaling rate of 0·005 gramme per square inch per hour were to be fixed as the maximum allowable, then nickel-chromium and carbon steel could not be used over 620 deg. C., high-speed steel could go up to 710 deg. C., high-chromium steel (stainless) up to 840 deg. C., and the nickel-chromium alloy up to no less than 1,070 deg. C.

The practical uses of this diagram are, in fact, sufficiently obvious, but it may be noted that, over 700 deg. C., the different steels maintain the same order as the temperature rises.

When the logarithms of the scaling rates were plotted against the temperature, as shown by Fig. 19, it was found that the plottings of each steel fell with reasonable precision along a straight line, particularly the lower points obtained in the more equable electric furnace. Irregularities in some of the upper points are quite likely to be due to inequalities in the working of the chromium steels, and the three steels containing nickel. The latter all showed the characteristic lower layer, containing a large proportion of metal, described and explained by Stead.* In the case of the 25 per cent. nickel steel, the lower layer is particularly well defined, as shown by Fig. 20, this explaining the "stopping" in the curves of this steel in Figs. 15 and 16. Although the outer, completely oxidised layer easily shells off, the inner is strongly adherent, and cannot be removed until it has reached considerable thickness. As this layer is distinctly malleable, and presents a very smooth metallic appearance, after the outer scale has been knocked away, it is easy, mistakenly, to suppose that no scale remains. This may account for several cases, of which the author has heard, where heated parts made of 25 per cent. nickel steel have apparently behaved very well for a time, and then suddenly collapsed. The carbon steels form a well-defined and completely oxidised scale, but, as illustrated by Fig. 21, above, there is some penetration of oxide membranes, apparently along the crystal junctions, into the underlying steel. The scale formed on the high-speed steel is very similar, but is even more cleanly separated, and there is little or no penetration of oxide below the smooth steel surface.

*ENGINEERING, vol. cii, page 367.

extension. Finally, he begs to express his thanks to Mr. William Clark, director of Messrs. Vickers, Limited, for permission to publish the results of these investigations.

AMERICAN COPPER.—The steady demand for American copper is still a feature of American export trade, says *The Iron Age*, New York. Its magnitude is a surprise even to those in closest touch with events in copper. The statistics show that shipments abroad for the fiscal year ending with June exceeded all post-war records, even the heavy movement in 1921. The actual figures are 677,487,300 lb., as compared with 596,117,247 lb. in the calendar year 1921. A continuing surprise is the heavy buying by Germany, despite the fall of the mark to a line's width from zero. At 33·7 per cent. of the total, exports to Germany exceed even the large buying in 1913 when stocks were being accumulated for war. Buying by France is also unprecedented at 16·6 per cent. of the total; and in the last six months Japan has increased her takings to 13 per cent. of the total against 9·9 per cent. in 1921. All these records are significant of the well-nigh indispensable place of the ancient metal in the world's work, and also of its historic capacity for doing the unexpected.

THE RESISTANCE TO FIRE OF CONCRETE AND REINFORCED CONCRETE.*

By Professor F. C. LEA, O.B.E., D.Sc., M.Inst.C.E., M.I.Mech.E., and R. E. STRADLING, Ph.D., M.Sc., Assoc.M.Inst.C.E.

(*Concluded from page 344.*)

Causes of Failure of Portland Cement Mortar and some Probable Critical Points.—Summarising now, the data and previous discussions, the writers would suggest the consideration of the accompanying table (Table III) as a short statement of the various factors which effect the failure of cement-sand (quartz) mortars or concretes.

Now to return to the case of sand-cement mortars and the experimental values obtained.

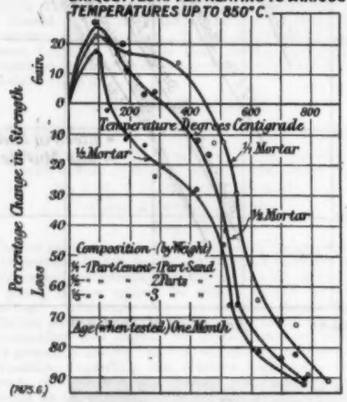
With the outline given in Table III in mind, we can, perhaps, analyse the actions taking place.

Experimental Data showing Reduction in Strength of Sand-Cement Mortars and Concrete.—Three sets of mortars were made up, their compositions (by weight) being as follows :—

1 part cement, 1 part Leighton Buzzard sand.
1 part „ 2 parts „ „ „
1 part „ 3 parts „ „ „

These were made into standard tension briquettes and tested when 28 days old. The specimens were made up, stored in water for 28 days and then heated either in a hot air oven or electric resistance furnace (depending on temperature required) until they had remained at the required temperature for at least two or three hours. The total time in the furnace was usually about 8 or

Fig. 10. TENSION TESTS OF CEMENT-SAND MORTAR BRIQUETTES AFTER HEATING TO VARIOUS TEMPERATURES UP TO 850° C.



9 hours. The briquettes were then allowed to cool in the furnace and tested for strength as soon as they were cold enough to handle.

The results are given in Tables IV, V and VI, and plotted graphically in Fig. 10. Each temperature-strength is an average of three briquettes.

The examination of the curves shown in Fig. 10 brings out very clearly the increase in strength due to the "drying out" of the cement just below 100 deg. C. The amount of this increase is probably not a definite quantity, but depends very largely on the time of exposure at the temperature. This increase in strength, shown in two of the curves as existing for some considerable increase in temperature, could probably be completely nullified by holding the specimens at 100 deg. or just over for a sufficiently long time (though this time is not of practical consideration, as it would quite likely be in the neighbourhood of some months).

Considering each curve in detail, it will be seen that in the case of 1:1 mortar the strength is increased by over 20 per cent. when heated to 97 deg. C.; with further rise in temperature the strength gradually decreases, starting to fall away rapidly in the 400 deg. to 500 deg. range. The effect of the quartz $\alpha - \beta$ transformation is also quite distinctly marked by the nearly vertical slope of the curve at this point. A similar action is seen in the 1:2 mortar, except that the fall off in strength occurs earlier, commencing about 200 deg. C. The $\alpha - \beta$ quartz point is well marked. With the 1:3 mortar, the failure occurs at or just above 100 deg. C., and the decrease is very rapid. In all cases the loss in tensile strength has dropped 75 per cent. of the strength unheated by the time 500 deg. to 700 deg. C. has been reached.

The actual loss in strength of 1 : 2 : 4 Portland cement concrete (by volume) when raised to 700 deg. to 800 deg. C. has been checked on many occasions, and varies from 60 per cent. to 80 per cent. With the $\alpha - \beta$ quartz point in mind, the obvious step was the making and testing of concretes not containing quartz in any appreciable quantity. Such material for aggregate seemed possibly to be available from the following sources :—

(1) Burnt clay products, *e.g.*, bricks etc.
(2) Natural rocks, *e.g.*, basalts, dolerites, etc.

Before making large numbers of concrete cubes, etc., such as are entailed in a strength-temperature investigation, some tension briquettes were made up. The proportions are given with Tables VII and VIII and correspond to the equivalent volumetrically of a 1 to 3 (by weight) cement-sand mortar. The two materials used were (1) red brick, of semi-vitrified type, a first-class red facing brick (actually the type used for this purpose at the Edgbaston buildings of the University of Birmingham); (2) fire brick, average commercial article used for lining furnace flues, etc. The values are given in Tables VII and VIII. In these cases we see that there is still a fairly marked effect between 500 deg. and 600 deg. C., though not as marked as in the case of sand mortars.

Thin micro sections were then made of these bricks, which soon showed quartz present. The relative strengths of (1) quartz sand mortar, (2) red brick mortar, (3) fire brick mortar, after exposure to a fairly high temperature can be realised from Table IX where the strength of each after exposure to 620 deg. C. is given.

Although it was realised the exact figures thus obtained did not give absolute values for concrete, yet it was considered sufficient to justify spending time in making up concretes of corresponding compositions.

Supplies of broken brick and scrap fire brick were obtained and broken to the following grades :—

(1) Large aggregate, to pass ¾-in. mesh, and retained on ⅜-in. mesh.
(2) Fine aggregate, to pass ⅜-in. mesh, and retained on 80 × 80 sieve.

Concretes were then made up of 1 part cement, 2 parts fine aggregate, 4 parts large aggregate by volume, and cast into 4-in. cubes. When 28 days old these were raised to various temperatures, and held there for two to three hours. The results are given in Tables X and XI.

These data are plotted in Figs. 11 and 12. It will be seen that both red brick and fire brick concrete are very superior to that made with ordinary quartz sand as a fine aggregate. The $\alpha - \beta$ transformation of quartz appears to be the final cause of failure with sand as a fine aggregate. The quantity of quartz present in the building brick and the fire brick does not seem to have any serious effect.

One other source of material for aggregate was also tried. A local dolerite (Rowley Rag) was used to form both tension briquettes and concrete. The experimental data for the tension briquettes are given in Table XII, and plotted in Fig. 13. The compression cubes have not yet been completed at the time of writing.

The general results given appear to indicate that Rowley Rag used for fine and coarse aggregate will make a more fire resistant concrete than quartz sand, but probably not quite so resistant as broken brick.

General Conclusions from Preceding Experiments.—It would appear from the experimental work already outlined that it is possible to make a concrete which retains sufficient strength at high temperatures to carry the full loads imposed by ordinary design methods, provided the temperatures concerned are not above about 900 deg. to 1,000 deg. C., average values to be reached in building fires. But such an assumption is only valid for the condition imposed upon the concrete during the experiments.

The experimental conditions which differed from practical ones are mainly two :—

(1) Concrete only was used in the experiments, and

TABLE III.

Temperature Range.	Effect of Heat. On Cement.	Effect of Heat. On Sand (Quartz).	Remarks.
deg. C. 0 to 98	Expands at about same rate as steel, but probably increases in strength	Expands, but relative expansion not yet sufficient to cause failure	
At 100 deg.	Begins to contract, and if held at this temperature the total contraction is greater than the previous expansion	Probably remains constant ..	This point is sufficient to cause failure if sand particles were completely covered and isolated.
100 to 300	Still contracting, the total at 300 deg. being about 2½ times as much as expansion up to 100 deg. C.	Still expanding	If failure has not occurred at 100 deg. C. the mortar usually starts to fall during this range.
300 to 491	Still contracting. The $Ca(OH)_2$ probably disintegrates during this range	Still expanding	Serious failure usually starts in this range.
491	Apparent change point. Commences to expand. (Dehydration of $Ca(OH)_2$ complete ?)		
491 to 575	Still expanding	Still expanding	
At 575	—	Change of α quartz to β quartz with linear expansion of about 0·4 per cent.	This usually completes the failure if not already completed.

TABLE IV.

1:1 (one part cement, one part Leighton Buzzard sand, 12·67 per cent water).

Temperature.	Percentage. Loss in Strength.
deg. C.	
97	− 22·3 (Gain)
166	− 16·3 „
200	− 16·9 „
360	− 13·4 „
510	+ 12·7 (Loss)
550	+ 29·9 „
625	+ 64·9 „
700	+ 71·6 „
750	+ 72·2 „
775	+ 90·7 „
790	+ 89·6 „
850	+ 91·1 „

TABLE V.

1:2 (one part cement, two parts Leighton Buzzard sand, 9·5 per cent water).

Temperature.	Percentage Loss in Strength.
deg. C.	
97	− 26·5 (Gain)
130	− 20·4 „
180	− 19·8 „
250	− 3·12 „
280	− 3·59 „
425	+ 12·6 (Loss)
463	+ 17·3 „
509	+ 41·4 „
580	+ 65·7 „
625	+ 82·4 „
700	+ 84·3 „
750	+ 82·5 „
775	+ 90·9 „
775	+ 91·8 „
850	+ 92·8 „

TABLE VI.

1:3 (one part cement, three parts Leighton Buzzard sand, 8 per cent. water).

Temperature.	Percentage Loss in Strength.
deg. C.	
97	− 16·8 (Gain)
130	+ 2·4 (Loss)
194	+ 11·3 „
250	+ 14·2 „
280	+ 24·3 „
425	+ 27·9 „
509	+ 47·1 „
580	+ 65·7 „
620	+ 83·8 „
775	+ 90·5 „

TABLE VII.

1 part cement, 2·5 parts red brick (by weight), 10·3 per cent. water, age 2 months.

Temperature.	Strength.	Loss. per cent.
Unheated	546	—
530 deg. C.	537	− 2·0 (Gain)
620 deg. C.	420	23·0

TABLE VIII.

(1 part cement, 2 parts fire brick (by weight), 15·7 per cent. water, age 2 months.)

Temperature.	Strength.	Loss.
		per cent.
Unheated	500	
530 deg.	390	22·3
620 deg.	318	36·4

TABLE IX.

Mortar.	Loss in Strength after Exposure to 620 Deg. C.
	per cent.
1/3 cement—Leighton Buzzard sand ..	80
Equivalent cement—Red brick	23
Equivalent cement—firebrick	36

* Paper read before Section G of the British Association at Hull, September 8, 1922.

was not associated with steel,* as is usual in most building work now.

(2) The strength was measured within a few hours of the cooling of the specimens which were allowed to cool in the furnace.

It is just these two further considerations which are of supreme importance in reinforced concrete work, considered as a fire-resisting material, and it is necessary now to examine these in more detail.

Effect of Rise of Temperature on Reinforced Concrete.—It has been pointed out earlier in this paper that if concrete is raised above 100 deg. C., then contraction is practically obliged to occur. On the other hand, steel embedded in the concrete still continues to expand as the temperature rises.

It is not difficult to realise what must happen. The adhesion between the steel and concrete must break

TABLE X.

(Red brick concrete, 1 : 2 : 4, by volume (strength, unheated, 3,500 lbs. per sq. in.) at 28 days.)

Temperature.	Percentage Loss in Strength.
deg. C.	
Unheated	—
200	— 11·5 (Gain)
300	— 18·85 ,,
400	— 12·45 ,,
500	— 16·60 ,,
550	— 5·43 ,,
600	— 6·38 ,,
650	0·19 (Loss)
700	2·11 ,,
800	11·05 ,,
900	35·40 ,,
1,030	55·30 ,,

TABLE XI.

(Fire brick concrete, 1 : 2 : 4, by volume (strength, unheated, 2,800 lbs. per sq. in.) at 28 days.)

Temperature.	Percentage Loss in Strength.
deg. C.	
Unheated	—
200	— 19·4 (Gain)
300	— 21·2 ,,
400	— 20·4 ,,
500	— 10·7 ,,
550	— 5·1 ,,
670	19·6 (Loss)
700	7·0 ,,
750	9·26 ,,
800	27·3 ,,
915	32·8 ,,

TABLE XII.

(1 part cement, 1 part Rowley Rag, by weight). Tension briquettes.

Temperature.	Percentage. Loss in Strength.
deg. C.	
Unheated	—
154	— 8·3 (Gain)
255	0·44 (Loss)
355	2·37 ,,
492	14·8 ,,
684	40·0 ,,
696	36·0 ,,

down either by a complete sliding of the steel through the concrete, or the concrete must crack and thus leave the steel in this way. In practice it is this latter which occurs. One has only to read the descriptions of the behaviour of reinforced concrete buildings during fires (*e.g.*, the Red Books of the Fire Prevention Committee) to realise that this is the case. One of the points on which great emphasis is laid is the "spalling off" of the concrete from the steel reinforcement, exposing the latter to the direct action of the fire.

With the amount of cover of concrete ordinarily allowed in design it is somewhat doubtful whether the question of heat conductivity of the concrete is of primary importance. This spalling action will, in many cases, occur long before the temperature of the steel can have risen to the degree which is dangerous. One of the writers has had opportunities of observing tests of large size slabs under fire conditions, in which spalling nearly always, if not always, preceded failure. The structure will fail due to the steel being heated to a point at which its strength is seriously affected, but this will usually happen by direct contact with the fire, and not by the heat conducted by the concrete. If a concrete which will not spall can be discovered the conductivity will be the only, and not by any means such a serious, menace.

This action will be seen to be most serious at the under side of beams and the sides of columns. It might be possible to counteract this effect by increasing the cover, but without actual large scale experiments it is not possible to say. Probably a type of burnt clay cover separated from the concrete by an air space or slag wool packed layer might be a solution, but again full scale experiments are required. It can now be said that the small scale experiments have shown, as anticipated by one of the authors, that much money has been wasted in large scale experiments which were carried out in an empirical manner without any real knowledge of the fundamentals of the problem.

The After Effects of Fire on Concrete.—Attention has been drawn to the fact that the specimens used in the experiments were all tested for strength within a few hours of heating. By accident on one occasion a specimen was left for about a week before testing. It was found to have lost strength quite out of proportion to the amount of heating. On leaving a previously heated concrete block exposed to the ordinary laboratory atmosphere for some days, the following is noticed :—

Though on removal from the furnace no cracks are apparent on the surface* yet quite soon these appear and after some days longer the block may crumble to pieces. It has not been possible to get the temperature

Fig. 11. STRENGTH OF BRICK CONCRETE AFTER HEATING TO TEMPERATURES 20 TO 1030°C.

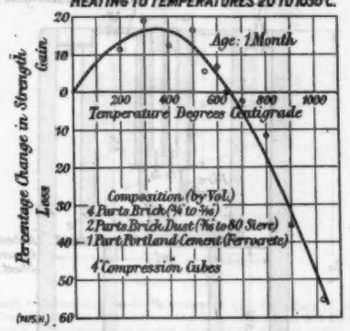

Age: 1 Month
Temperature Degrees Centigrade
Percentage Change in Strength Gain Loss
Composition (by Vol.)
4 Parts Brick (¼ to ¾")
2 Parts Brick Dust (¼ to 80 Sieve)
1 Part Portland Cement (Ferrocrete)
4 Compression Cubes
(NEAT)

Fig. 12. STRENGTH OF FIREBRICK CONCRETE AFTER HEATING TO VARIOUS TEMPERATURES TO 915°C.

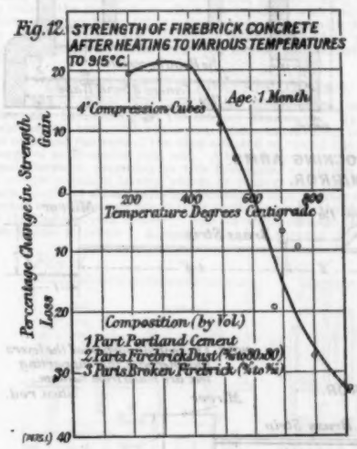
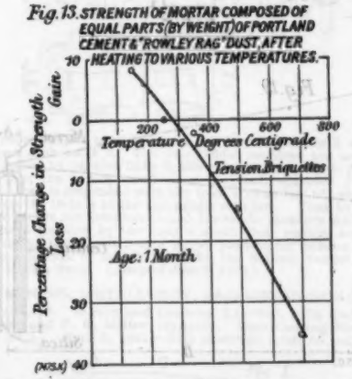

4 Compression Cubes
Age: 1 Month
Temperature Degrees Centigrade
Percentage Change in Strength Gain Loss
Composition (by Vol.)
1 Part Portland Cement
2 Parts Firebrick Dust (¼ to 80 Sieve)
3 Parts Broken Firebrick (¼ to ¾")
(NEAT)

Fig. 13. STRENGTH OF MORTAR COMPOSED OF EQUAL PARTS (BY WEIGHT) OF PORTLAND CEMENT & "ROWLEY RAG" DUST, AFTER HEATING TO VARIOUS TEMPERATURES.



accurately, but a lower limit for the previous furnace heating is about 400 deg. C.

The explanation of this phenomenon can be found in the fact that one of the chief products of hydration of Portland cement (as previously stated) is calcium hydrate. This dissociates into quick lime and water at about 400 deg. C.

$$Ca(OH)_2 \rightleftarrows CaO + H_2O$$

It must be realised that this is accompanied (as already shown) by a contraction of the concrete. Concrete is porous and the air getting in will carry moisture with it. This moisture will hydrate the quick lime again and the product of hydration ($Ca(OH)_2$) occupies a considerably greater volume and hence causes the concrete to crack, split and ultimately to crumble. A definite example is given under.

A set of 4 in. cubes (about six months old) composed of 1 part cement, 2 parts sand (Leighton Buzzard) and 4 parts Rowley Rag, were heated to 700 deg. C. The strength unheated was about 3,000 lb. per sq. in. Specimens dropped in water immediately after heating flew to pieces. The strength immediately after cooling was about 900 lb. per sq. in. The specimens were stored in the hydraulic laboratory and two days later the strength was above 780 lb. per sq. in. Six days after heating some had crumbled to pieces and could not be picked up, whilst two had an average strength of 535 lb. per sq. in. None of these blocks had any cracks on the surface immediately after cooling down, yet Figs. 14 and 15 show their appearance six days later.

FIG. 14.

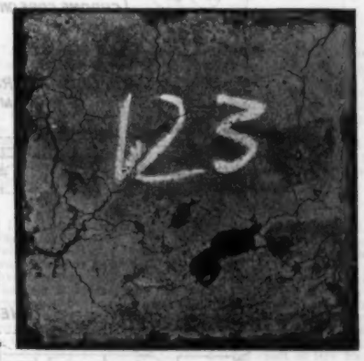


FIG. 15.

The importance of this "after effect of fire" cannot be over-estimated. Even although it might be possible, by using burnt clay products or dolerites, to make a concrete which will stand its full load at the time of the conflagration, yet when the question has to be faced as to whether the building is afterwards safe, and if not, how much of it should be demolished and rebuilt, the answer would appear to be not very encouraging.

In view of the very large number of buildings already erected in reinforced concrete, the problem cannot safely be left at this point, but in the opinion of the writers the next work should be done on full size specimens. The fundamental scientific principles on which an answer must depend have been outlined above, but the form of the answer for practical conditions of work depends upon one or two further factors which cannot satisfactorily be reproduced under laboratory conditions of the ordinary type. If money is available for further rather expensive work, very useful data could be obtained of primary importance to the community.

As far as the present results are concerned, it is submitted that reinforced concrete as at present carried out in practice is anything but fire resisting and the temperature of primary importance is a comparatively low one, probably about 400 deg. C., this being the approximate temperature of the dissociation of calcium hydrate.

But as important a point as the resistance during fire is that of the after effects. It is suggested that extremely careful and very skilful examination of reinforced concrete structures after a fire, is required, and it is highly probable that the original factor of safety can never be replaced in the building structure except by complete reconstruction

APPENDIX.

Apparatus Used for Measuring the Expansion of Neat Cement when Subjected to High Temperatures.

The general design of the heating unit and optical measuring arrangement of this apparatus is due to

* For strength of steel at various temperatures see paper by F. C. Lea, Brit. Assoc., 1920, and ENGINEERING, vol. cx, page 293.

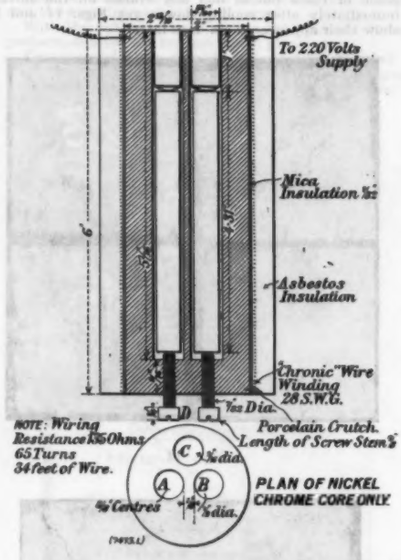
* See the 1920 paper already referred to.

Dr. G. A. Shakespear, senior lecturer in physics, Birmingham University, who used it in 1915 on some war work.

It consists essentially of a furnace so arranged that the difference between the linear expansion of the specimen and that of a standard rod of fused silica can be measured.

The heating unit consists of a nickel chrome cylinder 6 in. long and 2 in. diameter. This is shown in detail

Fig. 16. HEATING UNIT FOR APPARATUS USED TO DETERMINE EXPANSION OF CEMENT.



heating unit which is supported off the base of the jar by a fire-clay crucible which allows the heads of the set screws to hang inside. The space between the furnace and the jar is packed with Kieselguhr.

The annular space between the jar and the outside 9 in. drainpipe is covered with a cement mortar layer carried on an asbestos ring.

The Kieselguhr between the sides of the jar and the heating unit is covered by a layer of asbestos board.

Optical Measuring Arrangements.—The principle of the method used to measure the movement of the specimen, &c., is merely an optical lever consisting of a silica arm with a mirror at the end.

Fig. 17. GENERAL ARRANGEMENT OF APPARATUS USED TO DETERMINE EXPANSION OF PORTLAND CEMENT (OPTICAL LEVERS NOT SHOWN)

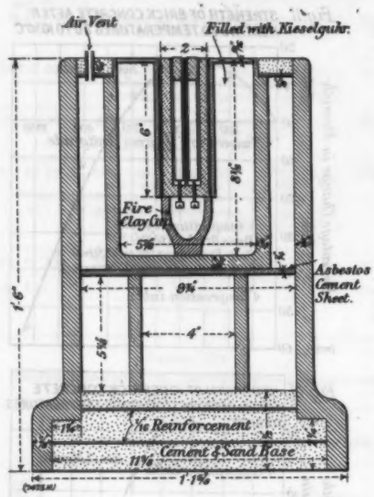
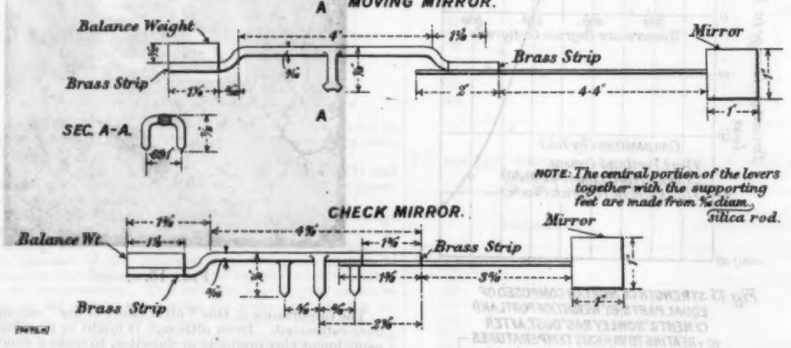


Fig. 18. MIRRORS AND ROCKING ARMS.



in Fig. 16. Three holes A, B, and C are drilled parallel with the axis of the cylinder. Holes A and B are $\frac{1}{4}$ in. diameter and about 5½ in. long and the third C is about 4½ in. long and $\frac{7}{32}$ in. diameter.

Into the bottom of each of the holes A and B passes a set screw D by means of which adjustment may be made of the positions of the specimen and silica rod which are placed in A and B.

As shown, the specimen and the silica rod are each about 4½ in. long and resting on the top of each is a plug of nickel chrome just fitting the hole easily. The lower end of each plug, resting on the specimen or the silica, is rounded, but the upper is plane.

By adjusting the set screws D the plane ends of the plugs can be brought flush with the upper surface of the cylinder or in any other parallel position within the limits of movement of the screws.

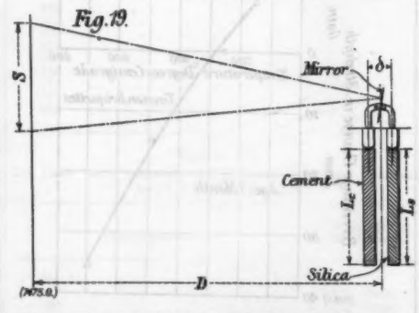
The outside of the cylinder is first covered with a layer of mica sheet ($\frac{1}{32}$ in.) and on this is wound the heating coil.

This coil consisted of No. 28 S.W.G. nichrome wire (Messrs. H. Wiggin's "Chronic"). The number of turns is about 65 and length about 34 ft. The total resistance is 135 ohms. The wiring was arranged so as to be non-inductive.

The external insulation is asbestos string and is wound on until the total diameter is about 2½ in.

The general arrangement of the heat insulation is shown in Fig. 17. It consists of an outer vessel formed from a commercial 9 in. stone-ware drainpipe 18 in. long; the bottom of which is formed by a 3½ in. layer of cement mortar. The chief reason for this base is merely to give stability to the whole furnace. Standing on this mortar base is a piece of 4 in. drainpipe 5 in. long. This is arranged centrally and carries on top a sheet of asbestos plaster sheeting.

Standing on this sheet is a stone-ware jar about 8½ in. deep and 6 in. diam., and in this is placed the Nichrome



There are two such levers. The first stands on three small silica feet of which two are on one of the nichrome plugs and the third foot resting on the other nichrome plug. Hence any relative movement between the specimen and the silica rod will cause the lever to rock and hence the mirror attached at the end. The second lever is merely standing on the top of the nichrome cylinder and is to register any movement of the furnace as a whole. Reading telescopes are placed in such positions that a scale can be observed reflected in the mirror. Hence any movement of the mirrors causes an apparent movement of the scale as seen against the cross wires in the telescopes.

A detail of the silica arms and these mirrors is shown in Fig. 18 and the magnification factor is as indicated below. It is assumed that the two plugs on which the feet of the optical lever stands are the same length.

In Fig. 19, if x_c = elongation of cement due to a rise of $t°$ C.

and x_s = elongation of silica standard due to a rise of $t°$.

and δ = distance apart of feet of optical lever.

D = distance between mirror and scale.
L_c = length of cement specimen.
L_s = length of silica standard.
S = difference in scale reading for a rise of $t°$.

Angle mirror moves through $= \frac{x_c - x_s}{\delta}$ (if expansion is small compared with δ).

Angle moved through by ray $= \frac{2(x_c - x_s)}{\delta}$

also $= \frac{S}{D}$

$$\therefore \quad x_c - x_s = \frac{S \cdot \delta}{2 \cdot D} \quad . \quad . \quad . \quad (1)$$

If C_c = coefficient of expansion of cement.

If C_s = coefficient of expansion of silica standard.

Then from (1)

$$C_c L_c t - C_s L_s t = \frac{S \cdot \delta}{2 D} \quad . \quad . \quad . \quad (2)$$

$$C_c - \frac{L_s}{L_c} C_s = \frac{S \cdot \delta}{2 D \cdot L_c \cdot t} \quad . \quad . \quad (3)$$

D = 18 ft. = 96 ins., δ = 0·691 ins., $L_c = L_s$ = 4·31 ins.

$$\therefore \quad C_c - C_s = 0{\cdot}000836 \; S/t.$$

CATALOGUES.

Tanks.—A catalogue of steel tanks with tables of the standard sizes kept in stock is to hand from Messrs. W. J. Fraser and Co., Limited, Dagenham, Essex.

Rotary Pumps.—A new catalogue of their two-tooth rotary valveless pump, with lists of capacities and various special forms, comes from the No-val Engineering Company, Limited, Gordon-street, Bradford.

Electric Furnaces.—A catalogue of furnaces, instruments and other equipment necessary for the heat treatment of steel, giving much useful technical information on this subject has been issued by Automatic and Electric Furnaces, Limited, 281, Gray's Inn-road, London, W.C. 1.

Commutator Smoothing Stones.—A list of artificial stones in various forms for smoothing commutators and specially prepared to cut freely without filling up the stone surface is to hand from the Electric Construction Company, Limited, Bushbury, Wolverhampton. Prices and dimensions are given of about 30 stones of several styles.

Machine Tools.—A catalogue of special tools for locomotive repair work is to hand from the Niles-Bement-Pond Company, of New York, whose London address is 25, Victoria-street, S.W. 1. The plant dealt with is sufficient to furnish a full equipment for the maintenance of all the rolling-stock, and the heavy machines are provided with special means for handling the work.

Electrolysers.—An apparatus for producing liquids for sterilising, bleaching and other purposes from common salt and water by means of an electric current is described in a leaf catalogue received from the makers, the Electrolytic Apparatus and Battery Company, Limited, Godalming, Surrey. A catalogue of small secondary cells has also been acquired from this firm. Both catalogues contain price lists.

Planers and Lathes.—A catalogue received from Messrs. C. Redman and Sons, Limited, Parkinson-lane, Halifax, gives a very full description of a variety of planing machines and of lathes ranges from 6½-in. centres to 14½-in. centres. The designs show that care has been taken to facilitate the production of accurate work at high speeds, and the catalogue is of considerable interest on account of the details given.

Driving Chains.—A new edition of their catalogue of chains for power transmission has been issued by the Coventry Chain Company, Limited, Spon End, Coventry, giving illustrations, tabulated dimensions, weights and breaking loads of inverted tooth, roller and special chains. This catalogue contains, as usual, a full supply of technical information in practical terms with numerous illustrations of exceptional or difficult applications of the chain drive. Chain wheels, cutters, connections, &c., are also dealt with.

Railway Track Material.—A carefully compiled and exceptionally complete catalogue of railway track material has reached us from Messrs. Thomas Summerson and Sons, Limited, Darlington. In addition to rails, fish plates, chairs, sleepers of steel and wood, gauge ties and the necessary fastenings, the catalogue deals with complete crossings, switches, turntables, buffer stops, wheel stops with all the necessary levers, rods, and other operating gear, as well as with steel and iron castings for tracks wheels, bollards, &c. The catalogue is notable for its completeness in illustration of these materials for standard light and narrow-gauge railways, and yard sidings, and also for the clear direction given for ordering to correct dimensions both for new lay-outs and for replacement work. Small accessories, such as bolts, screws, spikes, &c., are detailed with equal care so that a full choice and precise particulars are available. The catalogue, which extends to 150 pages, will be particularly acceptable to engineers in charge of track construction or repair work.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

179,647. A. B. Field, Marple, S. Neville, Hale, and Metropolitan-Vickers Electrical Company, Limited, Westminster. Rotors. (13 *Figs.*) February 2, 1921.—In an electrical generator having a cylindrical rotor, a damping circuit independent of end bells and clamping rings consisting of longitudinal and circumferential members of non-magnetic conducting material is provided on the rotor in the interpolar as well as in the polar portions, and disposed at a greater radius than the outermost turns of the rotor windings. The slot-closing wedges 4, Fig. 1, preferably constitute the longitudinal members and are of hard copper, &c., the ends being connected together by rings 6 of the same metal. The circumferential members 6 are preferably of dovetail section, as shown in Fig. 2, and are retained in the slots 7 in the wedges and rotor teeth by means of caulking strips 8 of soft copper. In some cases the rings 6 may be of soft copper so that the strips 8 may be dispensed with. To avoid

Fig. 1.

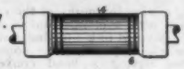


Fig. 2.

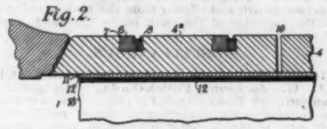


Fig. 3.

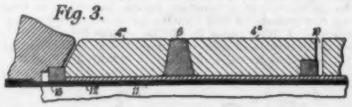


Fig. 4.

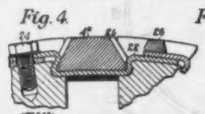
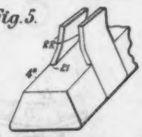


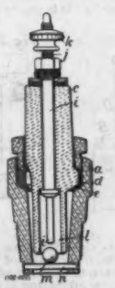
Fig. 5.



injury at the points due to expansion, the slot wedges may be divided into three parts, the end portions 4a being short in comparison with the central part 4, and a short gap 10 is left between them. Electrical connection between the sections is obtained by means of conducting strips 11 lying immediately above the slot-insulation 12, which strips are forced against the wedges by centrifugal action when the rotor revolves. Fig. 3 illustrates a construction in which the rings 6 extend to the bottom of the longitudinal members, and key rings or segments 16 are shown for preventing longitudinal movements of the ends 4a. Other methods of connecting and securing the members are described; in the form shown in Figs. 4 and 5, the wedge 4a has a groove 21 on its inner and sloping faces to accommodate a copper strip 22. When assembled on the rotor, Fig. 4, the ends of the strips are bent back and connected to the ends of adjacent strips by bolts 24 or wedges 26. (*Sealed.*)

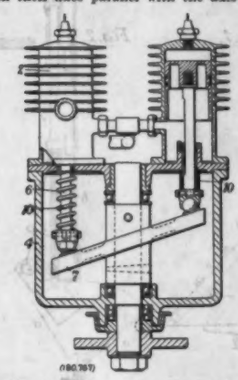
GAS ENGINES, PRODUCERS, HOLDERS, &c.

180,428. H. S. J. Hughes, Tottenham, and J. W. Hughes, Tottenham. Sparking Plug. (1 *Fig.*) February 22, 1921.—This invention relates to sparking plugs of the kind in which a metallic ball forms the lower electrode. According to this invention, the ball is so positioned relatively to the open end of the inner insulating tube that the tube wall always encloses part of the ball, at the same time permitting the ball to move freely with the vibration of the engine and to form a movable contact



between the lower end of the axial terminal rod and a lower rod disposed across the bottom of the plug body and serving to keep the ball in position. *a* indicates the plug body which receives the insulating tube *c* formed with an enlarged portion *d* for engaging the shoulder *e* in the plug body *a*, the shoulder *e* being grooved or serrated to form a seating for the packing ring which is placed between the part *d* and the shoulder *e* to ensure a gastight joint. *i* is the axial rod which carries at its upper end the terminal screw *j* and adjusting nut *k*. Within the orifice *l* of the bottom end of the member *c*, and immediately below the lower end of the rod *i*, is placed the metallic ball *m*, which is so disposed that a portion of its circumference is always enclosed by the wall of the tube *c* as shown. The ball *m* forms a movable contact between the lower end of the rod *i* and the rod *n*, which is preferably disposed diametrically across the bottom of the plug body and serves to keep the ball *m* in position. (*Sealed.*)

180,767. C. Wilson, Coventry, and W. H. Knee, Coventry. Internal Combustion Engine. (7 *Figs.*) March 5, 1921.—This invention has reference to internal-combustion engines of the kind in which the reciprocatory movement of the pistons is converted into rotary movement at the engine shaft by means of a face cam secured to the shaft and occupying a plane at an angle to the axis thereof, and in which the working cylinders are disposed with their axes parallel with the axis of the engine



shaft. According to this invention, the cylinders 2, which are arranged at one side only of the face cam 7 and are rigid with a casing 4 enclosing the latter, have their pistons rigidly secured to rods 6, the free ends of which are provided with ball-jointed shoes, the shoes being either maintained in contact with the plate by springs 10 disposed within the casing or held in positive sliding engagement therewith by means of annular rings. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

180,392. John Hill and Sons, Stourbridge, and W. Morrall, Stourbridge. Overhead Runways. (4 *Figs.*) February 10, 1921.—This invention relates to travelling carriages for overhead runways of the kind adapted to run on the bottom flange of an H-section joist rail. A travelling carriage for overhead runways, according to this invention, comprises a pair of saddle members having wheels or runners and connected to each other and a load carrying member in such manner as to be turned simultaneously about their vertical axes by the operation of the load-carrying member. The travelling carriage comprises two saddle members 1, 2, each of which is suspended from the

Fig. 1.

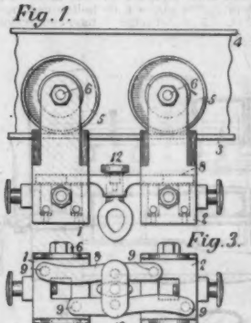


Fig. 2.

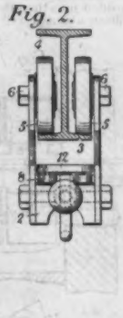
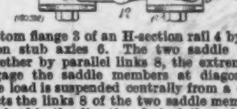


Fig. 3.



bottom flange 3 of an H-section rail 4 by two wheels 5 mounted upon stub axles 6. The two saddle members are connected together by parallel links 8, the extremities of which pivotally engage the saddle members at diagonally-disposed points 9. The load is suspended centrally from a cross bar 12, which connects the links 8 of the two saddle members. Thus by turning the load in the direction desired, the saddle members are suitably turned together by the links 8 about their vertical axes, thus bringing the wheels 5 to a proper position for passing through the openings or switch points in the bottom flanges of the H-section track. (*Accepted June 8, 1922.*)

MINING, METALLURGY, AND METAL-WORKING.

180,145. Mavor and Coulson, Limited, Mile End, Glasgow, and P. R. Miller, Halliside. Coal-Cutting Machines. (2 *Figs.*) April 5, 1921.—This invention refers to coal-cutting

Fig. 1.

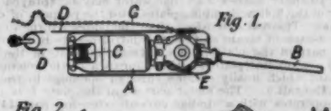
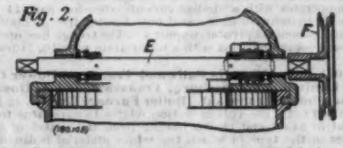
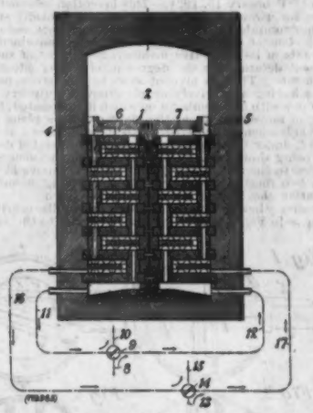


Fig. 2.



machines in which the cutter member is mounted to turn or be slewed angularly about an axis at right angles to the normal base of the machine, and in which a transverse driving shaft is provided for operating the slewing gear. This invention, which relates to the provision of improved means for rotating the driving shaft of the slewing gear, consists in providing a chain sprocket wheel to be fixed to rotate with the driving shaft and a chain at the end of the haulage rope (or chain) to be passed around the sprocket wheel and to be operated by the power driven haulage gear of the machine. A is the body of the machine, B the cutter bar, C the winding drum of the haulage gear, D the haulage rope, and E the transverse driving shaft for operating the slewing gear. The driving shaft E is formed with ends which project from the gear casing, each end being rectangular in cross-section, to receive the sprocket wheel F. G is the chain, the leading end of which is attached to the trailing end of the haulage rope D by a hook and eye connection. (*Sealed.*)

179,965. S. A. Sears, Levenshulme, Manchester, and W. R. Twigg, Luton. Furnaces. (10 *Figs.*) November 11, 1921.—This invention refers to furnaces, and it provides in combination with a furnace using producer gas, one or more preheating chambers each with a number of separate passages through them for the passage of air, gas or waste products, each of the passages being of tortuous form and reversed and staggered relative to the adjacent passage or passages, and each chamber of chambers having appropriate connections so that it or they can be used as a regenerator or recuperator or both. 1 is the hearth, 2 the combustion chamber, 4, 5 the air and gas inlets of the furnace.



The preheating chambers are indicated at 6 and 7. Air is supplied from a pipe 8 by way of a change-over valve 9 having a flue connection 10 to one or other of the branch pipes 11, 12, and similarly gas is supplied from a gas pipe 13 by way of a change-over valve 14 also having a flue connection 15 to one or other of the branch pipes 16, 17. The air valve 9 is set to supply air to be preheated through the pipe 12 to the chamber 7 and to pass the exhaust from the pipe 11 to the flue connection 10. Likewise the valve 14 is set to supply gas through the pipe 17 to the chamber 7 and to pass the exhaust through chamber 6, pipe 16 to flue connection 15. (*Sealed.*)

MOTOR ROAD VEHICLES.

179,700. Leyland Motors, Limited, Leyland, and J. G. P. Thomas, Preston. Variable Speed Gears. (5 *Figs.*) February 19, 1921.—This invention relates to the variable-speed gear described in Patent No. 115,267; and, according to the invention, the clutches are put into action by hydraulic means. The gear comprises four sun wheels 1, 2, 3, 4 and two planet wheels 5, 6 upon a common spindle 7 rotating in a carrier 16 formed upon the driven shaft 17, each planet wheel meshing with two of the sun wheels. Sun wheel 1 may be clutched either to the driving shaft 11 or to a stationary brake surface 22; sun wheel 2 may be clutched to the driving shaft or left free; the third and fourth sun wheels may be clutched to a brake surface or left free. To effect such clutching, the sun wheel 1 has keyed to, but sliding on, its shaft, a double coned member 12, 13 with a central web 21; within one coned surface 13 is a corresponding stationary brake surface; within the other 12 is a cone 9

Fig. 1.

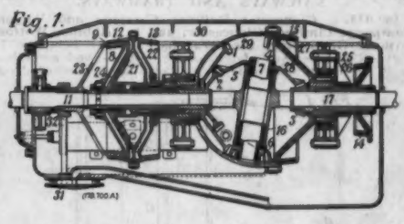


Fig. 2.

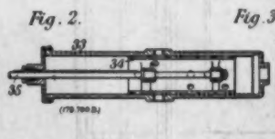
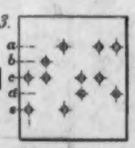


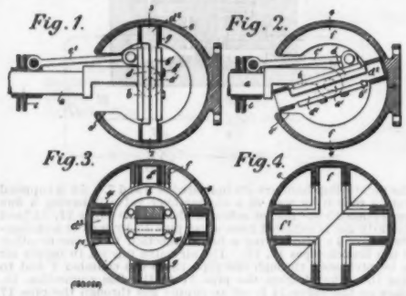
Fig. 3.



having clutch surfaces both inside and outside, which is joined to the prime motor shaft 11 and is not capable of longitudinal movement. Within this prime motor cone 9 is a corresponding cone 8 keyed to the shaft of the sun wheel 2 and capable of sliding along it. The prime motor cone 9 is carried by an open web 23 upon the prime motor shaft 11; but it has also a solid web 24 at its larger end journalled upon the hub of clutch 8. Thus three compartments are formed each substantially oiltight, except for the clearance between disengaged clutch members. The sun wheels 3 and 4 also have clutch cones 14 and 15 secured to them facing in opposite directions, and between these cones is a stationary bracket 25 in which two corresponding cones 26 and 27 can slide, but not rotate. Each of these forms with the sun wheel cone with which it co-acts a substantially oiltight chamber. To accommodate these clutches, a rotating casing is formed by the web 28 of the fourth and largest sun wheel and by a hemispherical shell 29 bolted to its outer rim and journalled

on the other side of the gear; and a stationary casing 30 is provided which covers the clutches as well as the gear, and contains a pump 31 driven by skew gearing 32 from the prime motor shaft, as well as the control valve which consists of a cylinder 33 connected at one end through a pedal-operated main tap (not shown) with the delivery pipe of the pump 31, and containing a sliding but non-rotatable sleeve 34, which can be moved lengthwise along the cylinder by a rod 35 connected to a gear changing lever (not shown). At about the middle of its length the cylinder has five ports marked *a*, *b*, *c*, *d*, *e*, occupying half its circumference. Each of these is connected with one of the oiltight compartments between the clutch members. Port *a* admits oil to the space between the closed web 24 of the prime motor clutch member and the web 21 of the double cone attached to the sun wheel 1; and the pressure of this oil brings the clutch parts 9, 12 into engagement, *i.e.*, connects the sun wheel 1 with the prime motor shaft; port *b* admits oil between the web 21 of the double clutch member 12, 13 and the adjacent stationary brake surface 22; port *c* leads to the space between the closed web 24 of the prime motor clutch member 9 and the clutch member 8 joined to the sun wheel 2; while the fourth and fifth ports *d* and *e* admit oil to the spaces between the clutch members 14, 15 of sun wheels 3 and 4 respectively and the corresponding non-rotating clutch members 26 and 27 beside them. (*Sealed.*)

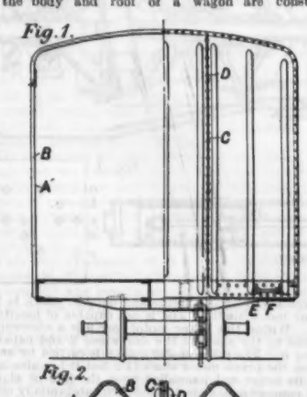
180,029. G. E. Pugh, London. Friction Clutches. (4 *Figs.*) February 15, 1921.—This invention relates to friction clutches for use with motor road vehicles. Broadly stated, the invention comprises driving and driven members, each carrying a clutch element which is capable of a tilting movement relative to the axis of its respective member, the extent of such tilting movement determining the degree of clutching effect between the elements. There is pivoted at a^1 to the driven member *a*, a disc *b* having a relatively deeply-grooved periphery b^1. The disc rotates with the member *a* on which it is mounted, but is also capable of movement about the pivot a^1 into a plane or planes at more or less acute angles to the axis of the member *a*, as indicated in Fig. 2, under the control of a manually-operated device, this device being shown as a collar *c* sliding on the member *a* and connected to the disc *b* by a link c^1. In the groove b^1 there are located two rings *d*, d^1 carried by the driving member *e* and constituting the driving elements of the clutch. The rings fit comparatively loosely into the groove when the disc is in its normal position, as in Fig. 1, in a plane at right angles to the axis of the



driving member *e*. The driving member *e* is a substantially spherical housing cut away at one side e^1 for admitting the end of the driven member *a* and provided with two guides *f*, f^1 (Fig. 4), arranged at right angles to one another. One guide *f* receives the trunnions d^2 of the ring d^1, and the other guide f^1 the trunnions d^3 of the ring *d*, and there are interposed between the trunnions and the guides, bearing members *g*, g^1, the co-operating faces of which are rectangular and the outer faces of which are similarly formed to fit the guides *f*, f^1. In the normal or unclutched position of the parts as indicated in Fig. 1, the rings *d*, d^1 are freely or loosely engaged in the groove b^1 of the disc *b*, and no driving effort is produced. To effect the clutching action, the disc *b* is given more or less angular movement about its axis a^1, for instance, into the position shown in Fig. 2, which causes the sides of the groove b^1 to grip or bind with a corresponding force against the faces of the rings *d*, d^1 and the rings against one another, and thus transmit the driving torque from one member to the other with a force corresponding to the extent of angular movement of the disc. (*Accepted May* 31, 1922.)

RAILWAYS AND TRAMWAYS.

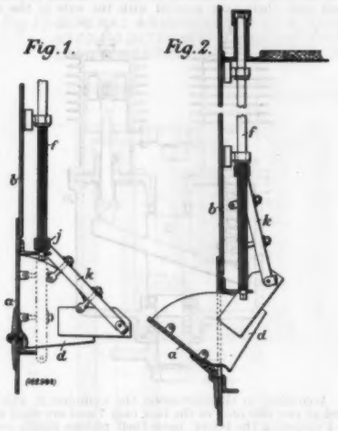
180,033. Gloucester Railway Carriage and Wagon Company, Limited, Gloucester, and F. Gibbins, Wotton Without, Gloucester. Steel Wagons. (6 *Figs.*) February 15, 1921.—This invention relates to steel wagons, and according to it the body and roof of a wagon are constructed of



corrugated steel plates having flanges along their sides, the plates being connected together by rivets D passing through the flanges C, which are preferably adjacent to corrugations in the plates. The body of the wagon is formed of plates A having corrugations B and flanges C forming right angles with the plates and running along their sides. The plates A are connected together by rivets D which pass through the flanges C. The plates A are also connected to the frame E by other rivets F, and extend along the side of the wagon and half across the roof, plates extending from each side being riveted together at the centre of the roof. (*Sealed.*)

SHIPS AND NAUTICAL APPLIANCES.

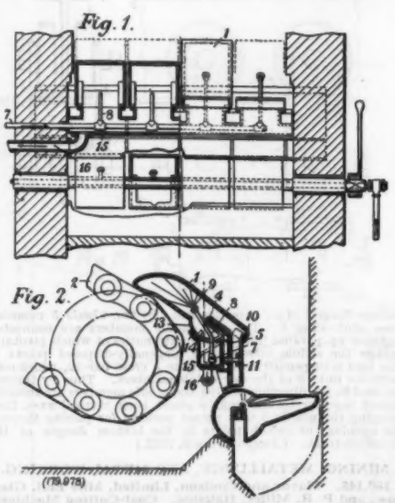
162,988. A. Powell, Middlesbrough. Opening and Closing Ports. (5 *Figs.*) August 26, 1920.—This invention relates to apparatus for opening and closing ports employed in charging coal into a ship through the ship's side. Apparatus made in accordance with this invention comprises a port *a* hinged along its bottom edge to the ship's side *b*, adapted to open externally and provided with internal side members or wings *d*



projecting through the port hole, a screwed shaft *f* in the interior of the ship extending from the ship's deck to the port hole, a nut or screwed collar *j* mounted on the screwed shaft *f*, and a connection comprising two connecting rods *k* from the screwed collar to the side members of the port. The arrangement of parts is such that when the collar *j* is moved along the shaft by rotating the shaft, the port *a* is opened or closed. (*Sealed.*)

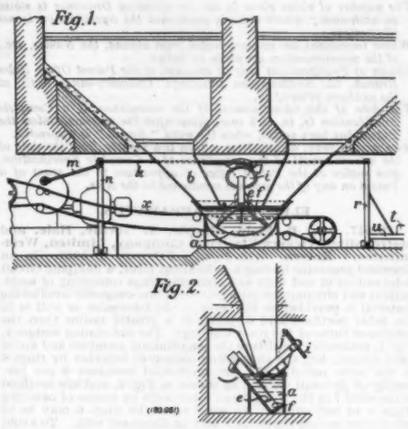
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

179,978. A. W. Bennis, Bolton. Furnaces. (2 *Figs.*) January 13, 1921.—This invention relates to chain grates, underfeed stokers and the like. A method of cooling hollow dumper plates and the like parts of furnaces, according to this invention, consists in spraying water into their hollow interior and providing outlets for the vapour so formed. A number of dumping plates 1 is arranged across the width of the grate to co-operate with the end of a chain grate stoker 2 so that ashes will be deposited into the ash pit. The plates 1 are hollow castings and oscillate about a rail 4. A water pipe 7 has connections 8



leading to spray nozzles 9 so that water may be sprayed in the interior of the hollow dumping plates 1 for the purpose of cooling the same. The rear extensions 10 of the plates 1 form a channel for the escape of steam so that this latter assists in the cooling of this part of the plates. The extreme ends 10 of the plates overlap a protector plate 11 which forms a further channel for the steam which finally escapes through openings in the lower part of the rail 5. The under part 13 of the plate 1 is curved and co-operates with a similar curved extension part 14 on a trough 15, thereby forming a seal but allowing free oscillation of the plate 1 about its pivotal support 4. The trough has openings in its base communicating with a water drain pipe 16. (*Sealed.*)

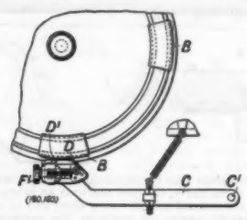
180,051. The Victoria Falls and Transvaal Power Company, Limited, Johannesburg, Transvaal, and A. Hossack, Johannesburg, Transvaal. Boiler Furnace Grates. (2 *Figs.*) February 18, 1921.—This invention relates to apparatus for the removal of ashes and clinker falling from the grates of boiler furnaces of the type in which the refuse material is discharged under a water seal into a container and removed by mechanical means. According to the present invention, a wheel having vanes is arranged within a tank and inclined at an angle of less than 45 deg. to the vertical, the driving shaft and bearing of the wheel being arranged above the tank. *a* is a tank fitted beneath ash hoppers *b* of a boiler and filled with water. *c* is a paddle wheel inclined at an angle of less than 45 deg. to the vertical and having paddles *f*, the spindle having at its upper extremity a ratchet wheel *i*. On this ratchet wheel works a pawl *j*, the carrier of which is clamped to a rope *k*. The rope is given a



reciprocating motion by means of the connecting rod *m* working in conjunction with a pivoted link *n*. The rope is kept taut by means of a pivoted link *r* having weights *t* applied to a platform *u*. The wheel operating the connecting rod *m* is geared to the motor driving a band conveyor *x*. In action the wheel *e* conveys ash and clinker from the tank *a* and discharges it over the top edge of the tank on to the band conveyor *x*. (*Sealed.*)

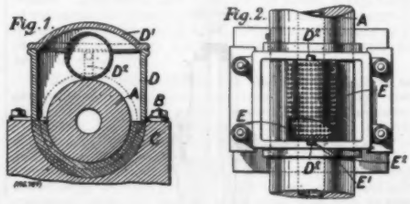
MISCELLANEOUS.

180,163. J. G. Jackson, Limited, Pollokshaws, Glasgow and J. G. Jackson, Pollokshaws, Glasgow. Cam Mechanism. (3 *Figs.*) April 16, 1921.—This invention refers to cam mechanism for producing angular or rectilinear motion intermittently of the character in which, assuming the operating part to be driven at a constant speed, provision is made for varying the periods of rest relative to those of operation. For convenience of description it will be assumed that the part to be operated consists of a lever C mounted to rock about a fixed axis C^1, and that a series of cams B mounted to rotate about



a fixed axis is provided for operating the lever. In this type of mechanism the lever C is provided with a tappet member, say, at its outer end for each cam in succession to act upon. According to this invention, the tappet member comprises two contact heads D, D^1 arranged longitudinally in alignment with the direction of motion of the cams B and generally at a distance apart, and provision is made for adjusting the longitudinal distance between the contact heads. One of the contact heads is fixed and the other adjustable. The adjustment of the head D^1 is effected by means of a screw F1, the head of which projects from the tappet end of the lever and by which it may be turned. (*Sealed.*)

175,767. J. Paterson, Watford. Lubricating Devices. (2 *Figs.*) November 24, 1920.—This invention relates to lubricators for journals, particularly those of parts of machines heated by fluid media, such as steam. According to the invention, a rotary container having its periphery perforated is constructed to receive a solid or semi-solid lubricant, and is arranged above and in rolling contact with a journal that is provided with means for heating it by a fluid. A hollow journal A of a shaft constituting a conduit for steam rests in a bottom brass B on a pillow C. No top brass is provided in this construction, but instead thereof a journal-box D is secured by studs to the pillow.



This box is rectangular as viewed in plan, has a detachable cover D^1 and is provided in the inner faces of its two end walls with vertical guideways D^2, each in the form of a slot vertically above the axis of the journal. A lubricator E in the form of a rotary container having a perforated periphery is so mounted in the journal-box as to be always in rolling contact with the journal, One end E^1 of this container is removable for filling the lubricator, and is normally securely closed by a set screw, not shown. The lubricator extends from end to end of the journal-box, but with sufficient clearance at each end to allow of free rotation, and has at the centre of each end a trunnion extending into one of the guideways. (*Sealed.*)